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# THE JANUARY SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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# THE SCIENTIFIC MONTHLY

JANUARY, 1935

## COLLECTING MICRO-ORGANISMS FROM THE ARCTIC ATMOSPHERE

By FRED C. MEIER

COOPERATIVE INVESTIGATIONS, BUREAU OF PLANT INDUSTRY AND  
WEATHER BUREAU, U. S. DEPARTMENT OF AGRICULTURE

## WITH FIELD NOTES AND MATERIAL

By CHARLES A. LINDBERGH

WHEN the red-winged monoplane piloted by Charles A. Lindbergh soared away from Flushing Bay on July 9, 1933, bound for aerial exploration near the Arctic Circle, there began an unusual botanical collecting trip. Mrs. Lindbergh was prepared to fly the ship during intervals when her husband might be occupied with manipulation of an instrument new to transatlantic airplanes—so new, in fact, that it was completed just in time for the writer to carry it by plane from Washington to New York to be added to other scientific equipment which had been assembled for the expedition. With this new device, which, being untried, was noncommittally called the "sky hook," it was planned to make collections of micro-organisms from the atmosphere along the course of flight. As an incidental feature of their aerial voyage, the two flyers were cooperating with the U. S. Department of Agriculture in its studies of the epidemiology of rusts and other plant diseases. It was also hoped that identification of materials collected at various altitudes between points on the course might contribute to our knowledge of the movement of air currents in northern regions.

### HISTORY OF AIR-CONTENT STUDIES

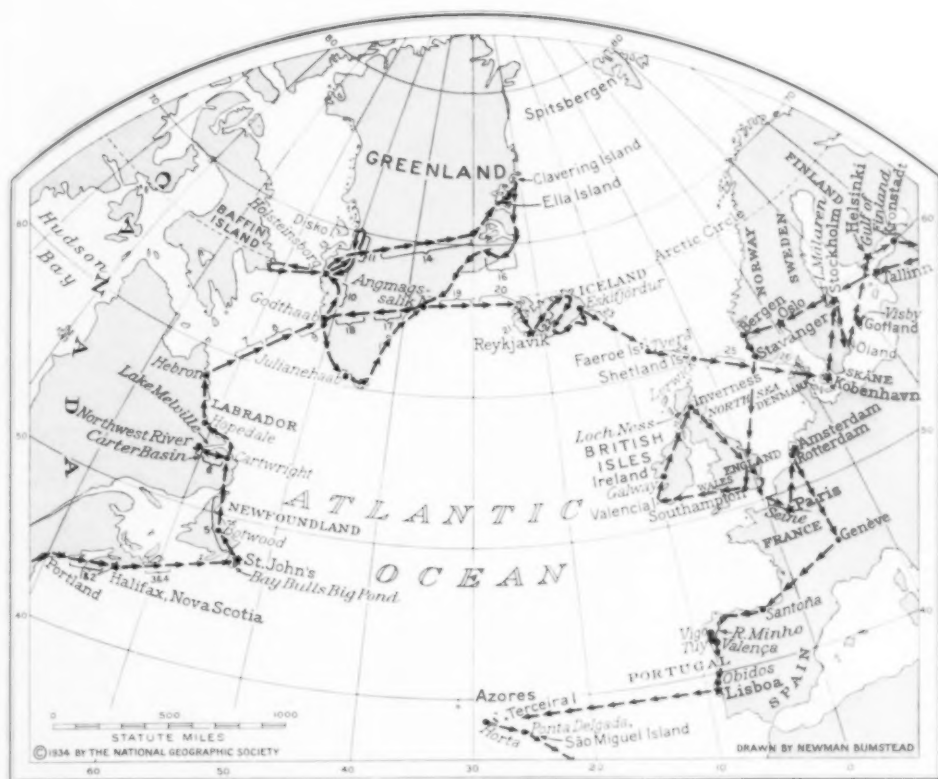
While it is generally known that bacteria, spores of higher fungi and pollen grains are present among dust particles in the atmosphere near the earth's surface, much detailed information of practical value remains to be revealed by further research. The aerial movement of pollen from certain flowering plants concerns the physician who deals with "hay fever" and related troubles. The plant pathologist and the medicopathologist are interested in obtaining facts concerning the part that air currents may play in disseminating reproductive bodies of organisms that cause specific diseases of plants and animals. Definite information of this sort is obviously an aid to a well-planned control program. As early as 1921 airplanes were used in making collections of rust spores as an aid to planning the barberry-eradication campaign for the control of stem rust of small grains. This work, by E. C. Stakman,<sup>1</sup> A. W. Henry, G. C. Curran, W. N. Christopher and pilots of the Army Air Corps, in the course of cooperative investigations of the U. S. Department of Agriculture and

<sup>1</sup> Stakman *et al.*, *Jour. Agr. Research*, 24, 1923.



*Photograph by Charles and Anne Lindbergh*  
FIG. 1. LOOKING WEST FROM OVER SCORESBY SOUND





*Courtesy of The National Geographic Society*

FIG. 2. MAP SHOWING ROUTES FLOWN AND POINTS BETWEEN WHICH COLLECTIONS WERE MADE. NUMBERS INDICATE INDIVIDUAL COLLECTIONS AND REFER TO RECORDS SOME OF WHICH ARE GIVEN IN FIGURES 8 AND 9.

the University of Minnesota, stimulated other such studies. Similar rust spore collections were later obtained by plant pathologists in Canada, Germany and Russia.

Since the microscope first came into use, studies of micro-organisms in the atmosphere have been of absorbing interest to botanists and medical men. It was in 1830 that Ehrenberg<sup>2</sup> first published on microscopic objects which he found present in atmospheric dust. Later he reported finding infusoria in a dust sample collected by Darwin when on board the *Beagle* near Porto Praya. Perhaps inspired by the studies of Ehrenberg, Berkeley,<sup>3</sup> in 1857, writes in

<sup>2</sup> Ehrenberg, *Ann. Phys. u. Chem.*, Jahrgang 1830, Viertes Stück, Vol. 17-18, pp. 477-514, 1829-30.

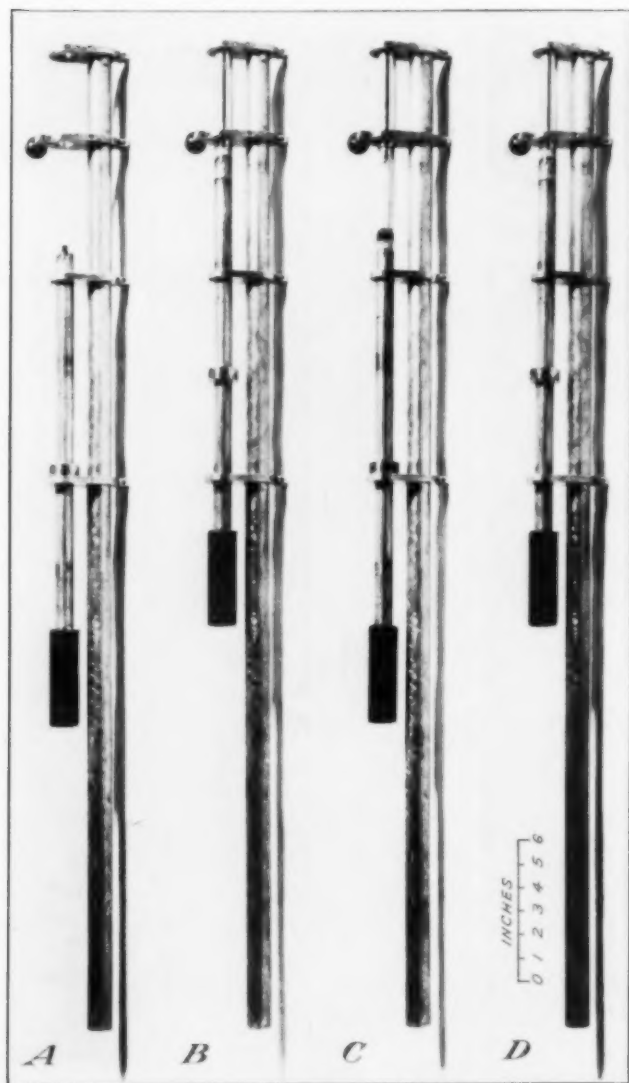
his "Introduction to Cryptogamic Botany";

Other spores are wafted about in the air, where they may remain for a greater or less period, till, obeying the natural laws of gravity, they descend in some distant regions. The trade winds, for instance, carry spores of Fungi mixed with their dust, which must have travelled thousands of miles before they are deposited.

Pasteur,<sup>4</sup> using an aspirator, conducted measured quantities of air through gun cotton, dissolved the cotton and examined the sediment with the microscope. By this means and his classical experiments involving the introduction of air from various sources into flasks of sterilized nutrient solution.

<sup>3</sup> Berkeley, "Introduction to Cryptogamic Botany," London, 1857, p. 258.

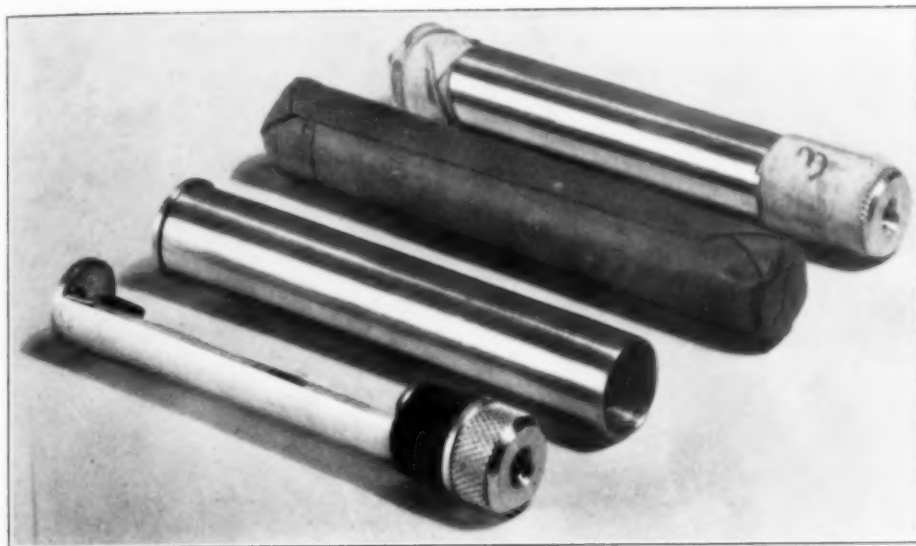
<sup>4</sup> Pasteur, *Compt. Rend. Acad. Sci. (Paris)*, 50, pp. 303-307, 1860.



Photograph by M. L. F. Foubert

FIG. 3. THE "SKY HOOK"

BUILT AROUND A PIECE OF ALUMINUM TUBING 1 INCH IN DIAMETER AND 42 INCHES IN LENGTH. WHEN IN USE, THE LOWER END OF THE TUBING SLIPS INTO A BRACKET PROVIDED FOR THE PURPOSE AT THE LEFT FRONT OF THE FORWARD COCKPIT. IN THIS POSITION, THE TUBING PROJECTS VERTICALLY TO A HEIGHT APPROXIMATELY 2 FEET ABOVE THE EDGE OF THE COCKPIT. THE UPPER END OF THE TUBING CARRIES TWO GUIDES INTO WHICH INTERCHANGEABLE ALUMINUM CARTRIDGES (FIG. 4) CAN BE SLIPPED AND FIRMLY FASTENED IN POSITION. AFTER THE UNEXPOSED CARTRIDGE IS ATTACHED TO THE HANDLE AND THIS IS CLAMPED INTO POSITION, THE ENTIRE OPERATION OF EXPOSING THE SLIDE AND RETURNING IT TO THE CONTAINER CAN BE CARRIED OUT BY MEANS OF AN ALUMINUM PULL-PUSH ROD OPERATED FROM BELOW, THUS AVOIDING DANGER OF CONTAMINATION FROM HANDS AND CLOTHING. ILLUSTRATION SHOWS: A, HANDLE READY TO RECEIVE CARTRIDGE; B, CARTRIDGE INSERTED AND READY TO BE PROJECTED INTO AIR STREAM; C, SLIDE PULLED INTO EXPOSURE POSITION; D, SLIDE RETURNED TO CYLINDER AFTER WHICH CARTRIDGE IS REMOVED AND SEALED.



*Photograph by M. L. F. Foubert*

FIG. 4. EACH SLIDE CONTAINER OR CARTRIDGE CONSISTS OF TWO MAJOR PIECES

ONE OF THESE IS AN OUTER SHELL MADE FROM A SECTION OF THIN-WALLED ALUMINUM TUBING  $4\frac{1}{2}$ " LONG AND  $11/16$ " INSIDE DIAMETER THAT IS PERMANENTLY SEALED AT ONE END AND OPEN AT THE OTHER. THE SECOND PART IS AN ALUMINUM ROD THAT IS CUT AWAY TO FORM A FLAT SURFACE THE LENGTH OF THE GLASS SLIDE. THE SLIDE IS FIRMLY ATTACHED TO THIS FLAT SURFACE BY MEANS OF A SCREW DEVICE. THIS INNER ALUMINUM BAR TERMINATES IN A CAP PIECE PROVIDED WITH A SEAL MADE OF A SHORT SECTION OF GUM-RUBBER TUBING HELD IN POSITION BY MACHINED POINTS. WHEN THE SLIDE IS IN THE CYLINDER, THE GUM RUBBER PROVIDES A SUFFICIENTLY TIGHT-FITTING CONNECTION TO PREVENT CONTAMINATION FROM THE OUTSIDE. WHEN THE BAR AND MOUNTED SLIDE HAVE BEEN WITHDRAWN TO THE EXPOSURE POSITION WITH THE PETROLATUM-COATED SURFACE FACING THE AIR STREAM, A CHECK RING ON THE CONTROL ROD STOPS THE WITHDRAWAL AT A POINT THAT LEAVES THE UPPER END OF THE SLIDE BAR SUPPORTED AGAINST THE LOWER RIM OF THE CYLINDRICAL CONTAINER. THE ILLUSTRATION SHOWS A SLIDE CARRYING BAR BEFORE BEING PLACED IN THE ADJACENT CYLINDER. BESIDE THESE IS A LOADED, PAPER-WRAPPED CYLINDER WHICH WAS CARRIED ON THE TRIP AND RETURNED UNUSED. AT THE EXTREME RIGHT IS AN EXPOSED CARTRIDGE AS RETURNED TO THE LABORATORY. IMMEDIATELY AFTER EXPOSURE THE CARTRIDGE WAS SEALED WITH ADHESIVE TAPE AND THE COLLECTION NUMBER WAS RECORDED. TAPE WAS APPLIED AT THE TOP TO PREVENT A POSSIBLE BREAKING AWAY OF THE CAP PIECE. THIS, HOWEVER, IN NO INSTANCE OCCURRED.

he proved that there are living bacteria and mold spores in the air and that the numbers vary considerably in different locations.

The many studies of air content conducted by nineteenth-century medical men in their efforts to combat epidemics of cholera and other diseases are reviewed by Cunningham<sup>5</sup> in a paper re-

<sup>5</sup> Cunningham, "Microscopic Examinations of Air," Calcutta, 1873.

porting his studies of air pollution, written while he served with the British Government as surgeon in India. Publication of this paper in 1873 stimulated bacteriologists in their studies of organisms present in the air around them.

Advances made in the development of aircraft early in the twentieth century made it possible to extend the scope of such investigations. All the earlier work was based on examination of air as

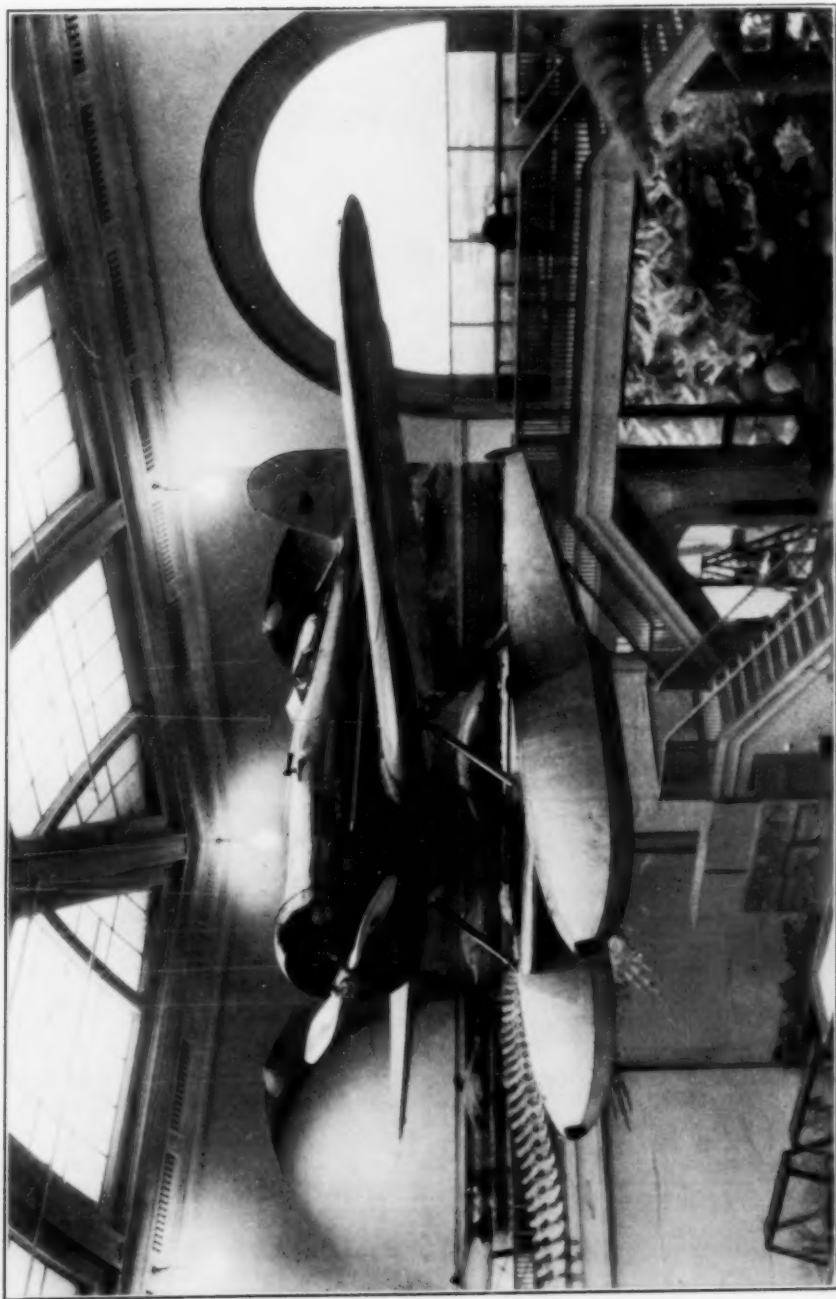


FIG. 5. *TINGMISSARTOQ*  
Courtesy of The American Museum of Natural History

IN THE HALL OF OCEAN LIFE, THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY. HERE THE SHIP IS SURROUNDED BY NUMEROUS INTERESTING EXHIBITS FROM THE LINDBERGH ATLANTIC SURVEY FLIGHT.

found near the surface of the earth. Although Pasteur considered the possibility of conducting experiments from a hot-air balloon, he decided that the method presented too many difficulties, so carried his flasks up the Jura Mountains and the Montan Verte, where exposures were made at 850 and 2,000 meters above sea level. The previously mentioned studies of rust-spore movement by use of spore traps on airplanes suggested new possibilities for study of dissemination of organisms that cause plant diseases.

For example, the writer<sup>6</sup> has obtained pure cultures of numerous fungi from spores which he collected during training flights of the naval airship *Los Angeles* in January and April, 1932, and from airplanes in the course of investigations begun in 1931 by the U. S. Department of Agriculture with the co-operation of the Navy, Army and Coast Guard air-service units. The ease with which vigorous cultures of fungi have been grown from spores collected during these airplane flights, which were made at various altitudes over widely scattered coastal, desert, mountain, forest and agricultural areas of the United States, emphasizes the probability of long-distance movement of viable spores of certain saprophytic and parasitic organisms.

The day-by-day situation with regard to presence of micro-organisms at different levels in the atmosphere over a given territory was discussed by Proctor<sup>7</sup> before the American Academy of Arts and Sciences in April, 1934. In his summary of studies of 201 separate collections secured from 45 airplane flights made over Boston by the Meteorology Division of the Department of Aeronautical Engineering, Massachusetts Institute of

Technology, he states: "Bacteria and molds were found above 19,600 feet, yeasts and pollens were found above 16,000 feet."

#### SIGNIFICANCE OF NORTHERN COLLECTIONS

Although, prior to the Lindbergh Atlantic Survey Flight, several investigators have used airplanes as an aid to study of micro-organisms present in air currents, such collections from the upper air have always been made over or near land in latitudes where numerous species of fungi growing on abundant local vegetation were constantly liberating spores. The opportunities for obtaining significant data on long-distance movements of spores and pollen would seem particularly good in the case of exposures made over water and ice of northern latitudes as compared with similar studies over land in the temperate zone, where the collector may be confused by much material originating from local sources (Fig. 1). The suitability of the course covered by *Tingmissartog* in 1933 for studies of this kind is evident from the photographs and excellent descriptions given in Mrs. Lindbergh's<sup>8</sup> story of the flight and from the route as indicated on the map (Fig. 2).

#### THE "SKY HOOK"

The collecting device for this particular trip was designed by Colonel Lindbergh (Figs. 3 and 4) with several requirements in mind. It should be compact, light in weight and simple to operate. The containers enclosing the collecting medium must be constructed to prevent contamination before or after exposure. They must be sufficiently

<sup>8</sup>Lindbergh, Anne Morrow. Foreword by Charles A. Lindbergh, *Nat. Geog. Mag.*, 66, pp. 259-337, 1934. In this story, Mrs. Lindbergh tells of the christening of the plane: "'Tingmissartog!' Eskimos shouted when the monoplane circled overhead. So *Tingmissartog* it became—'The one who flies like a big bird.'"

<sup>6</sup>Meier *et al.*, *Phytopathology*, 23, 1933.

<sup>7</sup>Proctor, *Proc. Amer. Acad. Arts and Sci.*, Vol. 69, No. 8, Aug., 1934 (Contrib. Dept. Biol. and Public Health, Mass. Inst. Technol., No. 29.)



*Photograph by Charles and Anne Lindbergh*

FIG. 6. REFUELING AT BOTWOOD, NEWFOUNDLAND



strong to stand possible rough handling without breakage. It was, of course, also important that the collecting medium used be such that material would remain in condition for examination some weeks or months after the sample was taken. Colonel Lindbergh's knowledge of pure-culture technique made him thoroughly aware of the necessity of developing a trap that could be used with minimum danger of error resulting from contact with dust in the cockpit. From discussion of these various requirements a plan was evolved for a modification of the oiled microscope slide trap. Glass slides with oiled surfaces have frequently been utilized in aero-

a culture room. After a mount carrying the petrolatum-coated glass slide had been inserted in each cylinder, with the gum rubber washer serving as a seal, a band of adhesive tape was applied. This served to prevent accidental opening. The surface of the entire cartridge and seal was then cleaned by moistening with alcohol, followed by thorough rubbing with sterile gauze, after which the cartridge was wrapped in clean sterile paper for protection until used.

#### CONTAMINATION FROM THE AIRPLANE UNLIKELY

The low-winged monoplane *Tingmisartok* is an exceedingly trim ship, as is



Photograph by Charles and Anne Lindbergh. Used by special permission. Copyright, National Geographic Magazine

FIG. 7. BLACK MOUNTAINS PUSH JAGGED POINTS THROUGH THE SNOW  
A TIP OF THE WING SHOWS IN THE PICTURE AS THE PLANE SKIRTS THE ICE CAP SOUTHWARD FROM  
CLAVERING ISLAND TO ANGMAGSSALIK.

scopes by investigators working on the ground, from roofs of buildings or from aircraft. After a design had been developed, the services of the American Instrument Company, of Washington, D. C., were enlisted. The personal interest taken in the project by both officers and employees of this company made possible "overnight" construction of the "Sky Hook" and fifty cartridges.

In preparation for these northern flights, the cartridges or slide containers (Fig. 4), after having been thoroughly cleaned, were loaded in the still air of

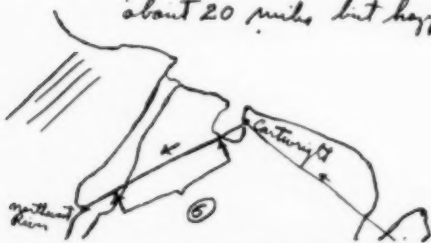
evident to those who have viewed her graceful lines as she hangs suspended, a central figure of the Lindbergh collection in the American Museum of Natural History (Fig. 5). Immediately forward and below the cockpit windshield is nothing but the smooth skin of the fuselage. The exhaust is carried away from the motor through a short stack below the fuselage. Directly ahead of the spore trap when in exposure position were the propeller tips only. In view of the fact that the writer frequently has found it possible to

Azimuths are given in degrees from true north and indicate direction from which wind comes

11

No. 5 - Will supply data later.

No. 6 - July 17 - 3:37 to 4:47 (Local time). Wind <sup>(from) (true)</sup> 245° about 10 m.p.h. Average altitude 4000 ft (2000 to 5500) Temp +12°C Air speed 115 m.p.h. Sky  $\frac{7}{10}$  to  $\frac{1}{10}$  overcast at about 8000 ft. Visibility about 20 miles but hazy.



No. 7 July 22. 17:24 g.m.s. to 18:24. Wind 270° about 15 m.p.h. Average alt. - 2500 ft. Temp. +12°C Air speed 110. Flying over low fog (500 about 1000 ft.) Clear above fog. ———, visibility about 100 miles. Apparently no rain for several days.

No. 8. July 22. 18:42 g.m.s. to 19:27. Wind 270° about 20 miles. Average alt. - 3000 ft. Temp +11°C. Air speed 110. Flying over low fog (500 about 1000 ft.) Clear and unlimited above fog.

No. 9 July 22. - 19:45 to 20:45 Wind 270° about 15 m.p.h. Average alt. 3000 ft. Temp +11°C Air speed 110. No fog. Clear and unlimited.

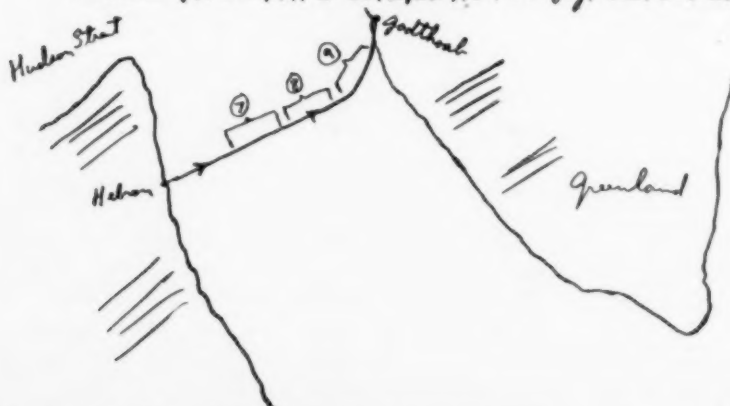


FIG. 8. PHOTOGRAPH OF ORIGINAL PENCIL NOTES SENT IN BY COLONEL LINDBERGH WITH THE SLIDE CONTAINERS. SIMILAR FREE-HAND MAPS WERE PROVIDED FOR EACH SLIDE DESCRIPTION.

- no (13) Aug 4, 1933 - 15:36 to 16:21 g.m.s. Wind  $90^\circ$  about 5 miles.  
Average alt = 5000 ft. - Temp. =  $0^\circ\text{C}$ . Air speed 110 miles.  
Sky 8/10 overcast at 10,000 ft. visibility unlimited. Lowest  
alt. = 4500.
- no (14) (Cotton) Aug 4, 1933 - 17:11 to 20:18 g.m.s. - Wind  
 $180^\circ$  about 40 miles at start of exposure. No wind at  
end of exposure. - Maximum alt = 12,500 ft. average = 10,000  
Temp. minimum =  $-12^\circ\text{C}$ . average =  $-9^\circ\text{C}$ . Air speed 110 miles.  
Completely overcast at 10,000 to 15,000 ft. (Due to the  
comparatively low temperature the rubber cap came  
out while the cylinder was being removed and the  
lower part of the slide was exposed on the cockpit  
for a fraction of a second. This may be sufficient to  
cause an erroneous positive result)
- no. (15) Aug 6, 1933 - 12:55 g.m.s. to 13:40. Wind calm except  
in fjords. Average alt. - 3,000 ft. Temp. =  $+6^\circ\text{C}$ . Air sp.  
115 miles. Sky clear and unlimited visibility.
- no (16) Aug. 6 - 14:40 to 15:40. Wind calm. Sky clear and  
unlimited visibility. Average alt 7000 ft. Temp. =  $-1^\circ\text{C}$ .  
Air speed 110 miles
- no (17) Aug 8 - 16:22 to 17:22. Wind  $45^\circ$  15 miles (From  
balloon observation) Sky less than  $\frac{1}{2}$  overcast (airies)  
visibility unlimited. Average alt. 8000 ft. Air temp. =  $-8^\circ\text{C}$ .  
Last 20 minutes completely overcast at 9000 ft (Plane flying below clouds  
and shifted to North least about 20 miles.

FIG. 9. PHOTOGRAPH FROM ORIGINAL PENCIL NOTES SENT IN BY COLONEL LINDBERGH WITH THE SLIDE CONTAINERS. NUMBERS REFER TO EXPOSURES INDICATED ON THE MAP (FIG. 2).

secure clean slides during exposures at high altitudes, made by projecting the collecting device over the side of the rear cockpit of a biplane with the many surfaces ahead to collect dust when the plane is on the ground, it is evident that the rush of air when in flight quickly and thoroughly removes dust particles from these surfaces.

This particular ship had no such surfaces ahead. Being a seaplane, refueling was carried on under conditions relatively free from dust stirred up by surface winds (Fig. 6). Moreover, the speed of flight and consequent effectiveness of air washing were greater by 30 m.p.h. than those obtained in biplanes ordinarily used by the writer.

## TWENTY-SIX SLIDES EXPOSED

Twenty-six collections were made during the period from July 11 to August 26 on flights between North Haven, Maine, and Copenhagen, Denmark. Many of these were obtained while flying over vast expanses of water, ice and bleak mountainous country (Fig. 7). With the expectation that the atmosphere of the far north would be thinly populated with organisms, if any at all were present, long exposures, thirty minutes to sixty minutes, were made. In previous work in southern latitudes exposures of three to ten minutes at air speeds ranging from eighty to one hundred eighty miles per hour have been found by the writer to give good results. The territory covered is indicated on the map shown in Fig. 2. Field notes by Colonel Lindbergh, similar to those shown in Figs. 8, 9 and 10, give circumstances surrounding each collection, making possible interpretation of results. It must be remembered, however, that frequently several days intervened between collections. During these periods the botanical relationships were, of course, changing as the season advanced. Wind direction and velocities varied at times when different collections were made. Moreover, unknown air movements and atmospheric changes were taking place between collections. These factors must all be considered in attempts at correlating results.

In an account of the work sent from Reykjavik Colonel Lindbergh wrote:

Before opening for exposure, all the cylinders were left in the air stream from three to five minutes. They were all closed while still in position and were sealed with adhesive tape without again being opened. It was not possible, however, to avoid sometimes touching the knurled end, and the tape, of course, was exposed to the turbulent air in the cockpit.

Hence, at his suggestion, before the slides were removed for laboratory examination, the exterior of the cylin-

ders, including the area covered by the tape, was flamed to destroy any microscopic objects which might have adhered.

## EXAMINATION OF SLIDES

Following their return to Washington, the cartridges were left unopened until each slide could be studied. In preparation for examination, the cylinder was flamed, the slide was removed in the still air of a culture chamber, and a permanent mount was made. This was done by adding a small quantity of filtered lactophenol to the exposed surface, covering the preparation with a flamed clean strip of No. 1 cover glass, and, finally, after the preparation had been allowed to rest several days in a desiccator, sealing it with lanolin cement. Counts were then made over a five square centimeter area while traversing the slide laterally with a three millimeter dry objective and 15x ocular, and photographs were taken of distinctive spores or pollen grains with this same lens combination. In some instances the camera lucida was employed for the work of recording. The position of different objects was recorded on the mechanical stage, and descriptive notes, including ocular micrometer measurements, were made of distinctive types.

## CHECK SLIDES

Six slide containers, returned unused after having been carried throughout the trip, were employed as checks. Careful microscopic examination of the slides within demonstrated these to be free from spores and pollen grains.

Numerous examinations of petrolatum from the lot used in preparing the slides for the trip, likewise gave confidence in results obtained.

## DISCUSSION OF RESULTS

In these collections are found spores of fungi, pollen grains and fragments of

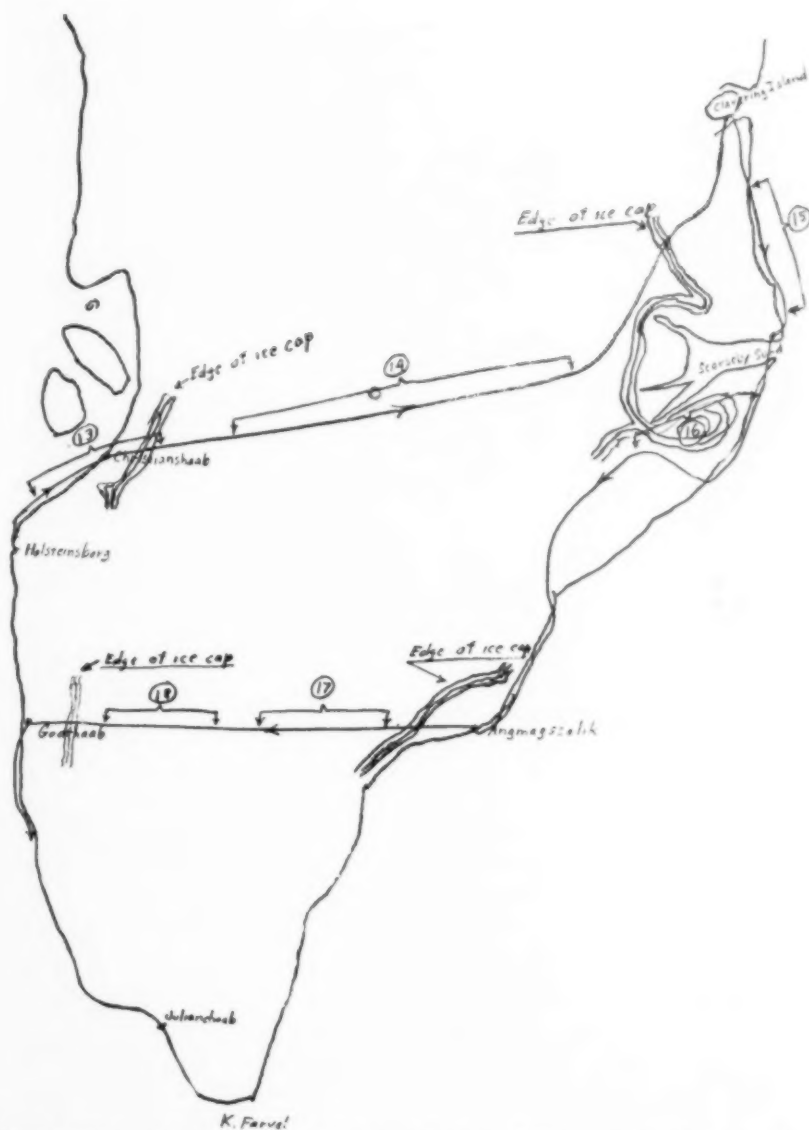


FIG. 10. ROUTE MAPS DRAWN IN THE FIELD BY COLONEL LINDBERGH SERVED TO MARK POINTS BETWEEN WHICH COLLECTIONS WERE MADE.

fungous hyphae. In some instances the asci of certain fungi, apparently carried up just before discharge of spores, were caught, the spores being spattered about by the impact. In addition were found unicellular algae, fragments of filamentous algae and insect wings, diatoms, objects tentatively identified as sponge spicules, volcanic ash and glass, and other microscopic débris of the air.

It is not the purpose of this paper to give detailed descriptions of the fungous spores caught. Instead, descriptions, tentative identifications and correlation of information obtained from different slides are reserved for a later paper. The two figures 11 and 12 will, however, serve to give an idea of the variety of material collected over Davis Strait and Northeastern Greenland.

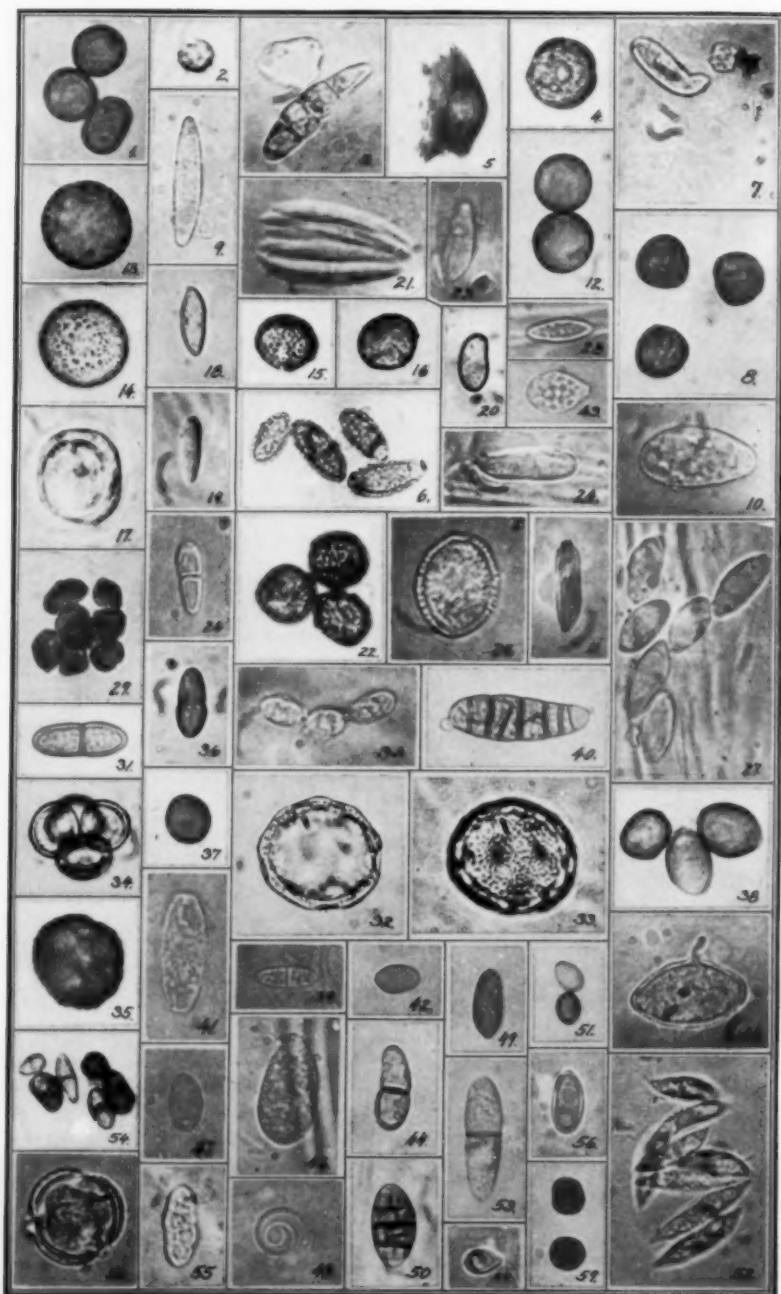
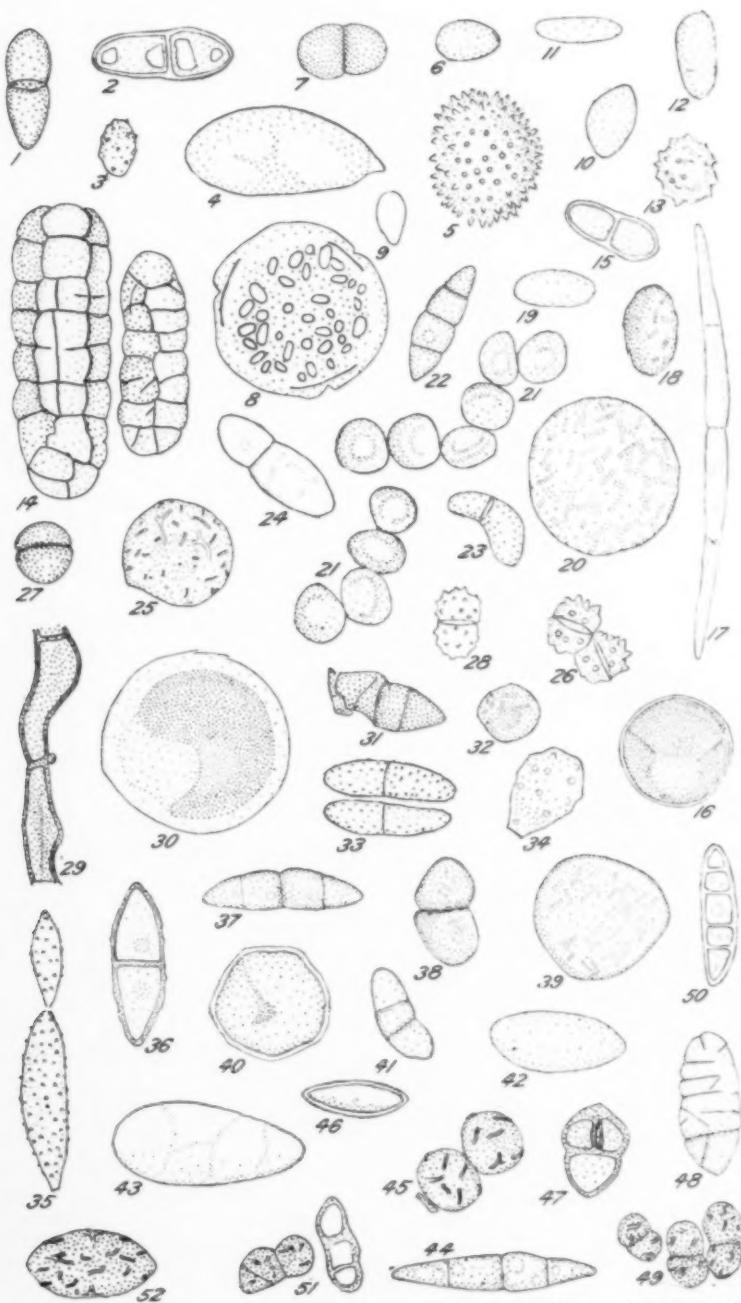


FIG. 11. SOME OF THE MORE CONSPICUOUS OBJECTS FOUND ON SLIDE 9. X 660. (SEE FIGS. 2 AND 8.)

Photomicrographs by F. C. Meier





From camera-lucida drawings by F. C. Meier

FIG. 12. TYPES OF OBJECTS TRAPPED ABOVE THE ARCTIC CIRCLE ON SLIDE 15. X 970. (SEE FIGS. 2 AND 9.)

Fig. 12 is the result of a careful examination of five square centimeters surface of slide 15. This slide was exposed on August 6 for forty minutes at an average altitude of 3,000 feet above sea level over the coast of Greenland between Scoresby Sound and Clavering Island, north of 70 degrees latitude and well above the Arctic Circle. Wind was from the west, about 15 m.p.h. The complete data for this exposure are given in Figures 9 and 10. Fifty-three different types of objects were found on this slide, duplication of some bringing the total number up to one hundred and ninety-three. A similar area on slide 9, exposed over Davis Strait sixteen days earlier than slide 15, was found to contain approximately 70 different objects and a total of 238 (Fig. 11). This slide was exposed for 1 hour on July 22 at an average altitude of 3,000 feet as the plane approached Godthaab, Greenland. Wind was from the west about 15 m.p.h. (Fig. 8). Nearest land to windward was Labrador.

Critical study of such slides must obviously be limited to objects that have sufficient size and character to make possible their identification. Often in the case of fungous spores, it is impossible to establish identity. In other instances, one can at least feel sure of the genus. Often the presence of a bit of mycelium or relationship of similar spores on the slide gives a clue. Plant pathologists, mycologists and other botanists acquainted with pollens will recognize certain familiar types among those shown on Figures 11 and 12. Among the spores on those two slides are forms which have been tentatively assigned to various genera, among them being *Macrosporium*, *Cladosporium*, *Leptosphaeria*, *Mycosphaerella*, *Trichothecium*, *Helicosporium*, *Uromyces*, *Camarosporium* and *Venturia*. It is hoped that with the aid of specialists on dif-

ferent groups of fungi, lichens, mosses and flowering plants the number of positive identifications may be increased.

Writing in *Mycologia* early in 1934, Jakob E. Lange<sup>9</sup> says:

But stronger and more lasting than any other impression is the evidence of the wonderful cosmopolitanism of the Agarics. When you have once found, in a Danish Sphagnum-bog, a few specimens of the "new" species *Stropharia psathyroides* Lange, it gives you a shock to meet with the very same plant in a bog in Oregon, near the Pacific Coast—and only an hour later to come upon *Lepiota cygnea* Lange, of which the only known specimens were hitherto those gathered in 1925, a few miles from my Danish home!

Who can trace the aerial course of the spore!

This Lindbergh collection of micro-organisms from the atmosphere is the first of its kind to give concrete evidence of the part played by air currents in distribution of fungi between northern lands. The slides show certain spore types to be abundant over Maine and Labrador and present in diminishing numbers as collections progressed to leeward over Davis Strait, the great ice cap of Greenland and Denmark Strait. Some of the spores of fungi caught at different points show definite evidence of having been alive when trapped, for they started to send out germ tubes in the unfavorable petrolatum medium. While, as would be expected, the collections show this northern air to be more thinly populated with micro-organisms than that over the continents in more temperate regions, it must be realized that, when one viable spore is precipitated to water or vegetation under surroundings capable of sustaining growth, reproduction may be very rapid. The potentialities of world-wide distribution of spores of fungi and other organisms caught up and carried abroad by transcontinental winds may be of tremendous economic consequence.

<sup>9</sup> Lange, *Mycologia*, 226, pp. 1-12, 1934.

## WHEN WILL LASSEN PEAK AGAIN ERUPT?

By ARTHUR HOLMES

PARK RANGER, NATIONAL PARK SERVICE, U. S. DEPARTMENT OF THE INTERIOR

IN one sentence, the year 1980 is given as the probable date that Lassen Peak, the most recently active volcano in continental United States, will again burst into action. Nature works in a mysterious way, albeit according to laws as yet little known by man, and to attempt to set a definite date on which this volcanic region will again speak in tongues of fire is at best somewhat presumptuous for mere man.

However, this prediction is based upon scientific observation. It is from Japan that there comes an inkling of the ways of volcanoes and what may be expected from them. The late Dr. Omori, professor of seismology at the Imperial University of Tokyo, after years of study found that many Pacific volcanoes erupt in definite periods of 130 years, with less frequent occurrences at half periods, or 65 years. According to R. H. Finch, U. S. Geological Survey volcanologist, Kilauea Volcano in Hawaii National Park is one of the volcanoes that has been found to definitely follow this 130- and 65-year period.

Lassen Peak, in Lassen Volcanic National Park, California, was last in eruption during the years from 1914 to 1917. The climax of these eruptions occurred in 1915. Let us add 65 years to 1915. The resulting date, 1980, is likely to witness the approximate time of the next outburst, if the periodicity of eruptions noted above is applicable here.

But 1980 is a long way off, and most of us need have no worries for what that date will hold. So let us go back a bit. Can these findings of Dr. Omori be checked in any way in their relation to the Lassen country?

If 65 years were subtracted from Lassen's last eruptions, the climax of which occurred in 1915, the resulting date would be the year 1850. That year

saw the dawn of California history. Settlers were moving into the great Sacramento valley, some 50 miles west of Lassen. Indians inhabited the mountains. And behold, both Indians and white settlers report that the skies were lit up with a brilliant red glow and remained so for many nights. Some miners traveling through the Lassen country report hot lava and volcanic activity in the winter of 1850-1851. The geologist Harkness<sup>1</sup> reliably sets the date of the last eruption and lava flow from the remarkable Cinder Cone, only 10 miles from Lassen Peak, as the winter of 1850-1851.

There is reason to believe that about 130 years earlier the mighty Chaos Crags were literally pushed up to their present height of over 1,800 feet. These crags, symbolic of all that the name implies, are directly north, and connected with, Lassen Peak. In fact, they were pushed up to such a height that the tops crumbled over and avalanched down to form the Chaos Jumbles, across which the scenic Lassen Peak Loop crosses.

J. S. Diller, one of the pioneer geologists of the Geological Survey in 1915, concluded that the Chaos Crags might have been formed about 200 years ago, an estimate that has since been corroborated on the evidence of vegetation by Professor Howell Williams, of the University of California.<sup>2</sup>

An outburst did occur exactly 65 years ago, and another 200 years ago, which are within the periods given by Dr. Omori. While these eruptions occurred not on Lassen Peak itself, the

<sup>1</sup> H. A. Harkness, "A Recent Volcano in Plumas County," *Proc. Calif. Acad. Sci.*, Vol. 5, pp. 408-412, 1874.

<sup>2</sup> H. Williams, "Geology of the Lassen Volcanic National Park, California," *Bull. Dept. of Geol. Sci., Univ. of Calif.*, Vol. 21, No. 8, p. 347.

source, nevertheless, was the same. It adds to the fascination of the region *not* to know exactly where to look for the next outburst of volcanic activity.

All of which is an interesting speculation, but it gives the park rangers in Lassen Volcanic National Park some basis upon which to answer the daily inquiries by park visitors, "Is there any chance of Lassen erupting while I am here?" "When will it erupt again?" "Can I climb up and look into the crater?" and similar questions.

Lassen Volcanic National Park in Northern California was set aside by Act of Congress in 1916 to protect but at the same time make accessible to the public Lassen Peak, the Cinder Cone,

Chaos Crags and the wealth of other intensely interesting volcanic, glacial, scenic and recreational features found here in such abundance. The park is administered by the National Park Service through the local park superintendent. A corps of park rangers, naturalists and engineers assist the superintendent in his work.

Lassen Peak is naturally the central point of interest. It startled the world by bursting into eruption in 1914, after having been considered entirely inactive. In fact, the U. S. Forest Service first used Lassen Peak as a fire lookout station in 1912. Needless to say, the building was blown to bits, although no one was injured, because the eruption



*Photograph by Chester Mullen*

A DOUBLE ERUPTION OF LASSEN PEAK,  
AS SEEN FROM THE TIMBERED SHORES OF REFLECTION LAKE, IN LASSEN VOLCANIC NATIONAL  
PARK. THE UPPER CLOUD IS FROM A BURST OF SMOKE AND STEAM, AND BEFORE IT BLOWS AWAY  
ANOTHER OUTBURST CAN BE SEEN RISING FROM THE CRATER OF LASSEN PEAK. TAKEN OCT. 6, 1915.

LASSEN PEAK<sup>1</sup>

THE MOST RECENTLY ACTIVE VOLCANIC MOUNTAIN IN CONTINENTAL U. S., AS SEEN FROM BROKEOFF MOUNTAIN. THE TONGUE OF LAVA WHICH FLOWED OUT DURING THE 1915 ERUPTIONS CAN BE SEEN EXTENDING DOWN FROM THE FLAT TOP OF THE PEAK. THE DARK SKY AND LIGHT-COLORED TREES ARE DUE TO THE PECULIARITIES OF THE PHOTOGRAPHIC PLATE. AN INFRA-RED NEGATIVE WAS USED, WHICH HAS THE UNCANNY PROPERTIES OF PENETRATING HAZE TO DISTANCES THAT CAN NOT BE SEEN WITH THE HUMAN EYE.

occurred early in the season (May 30) before any one was stationed there. Likewise, needless to say, the government has never considered it exactly prudent to replace the lookout station.

In 1915 two major eruptions resulted in the devastation of a large area on the north side of Lassen Peak. The park highway crosses the path of the flood and gas blast, and visitors find the section one of the most interesting and spectacular in the park. At this same time, May, 1915, molten lava welled up in the vent and filled the crater so that to-day Lassen Peak is comparatively flat-topped.

Following the outburst of 1915, dozens of eruptions took place at frequent intervals, but with decreasing intensity,

<sup>1</sup> Photographs by author unless otherwise noted.

until 1917, when the last authentic eruption was recorded. Officially, Lassen Peak is the most recently active volcano in the continental United States, which excludes the active volcanoes in Alaska and Hawaii.

So much interest was displayed by the public in Lassen Peak that the first development to be undertaken in the park by the Federal Government was the construction of a standard, high-gear, paved highway to the very foot of this mighty volcanic mountain. Two years ago a fine trail, only  $2\frac{1}{2}$  miles in length and with a maximum grade of 15 per cent., was completed from this highway up the steep sides of Lassen Peak to the very top. From the register established on Lassen comes the interesting information that last season 5,255 visitors actually climbed this mountain and placed



their names in the little book at the top. Many others made the climb, but for one reason or another failed to register. With the new trail, however, it is now a comparatively easy hike, and every Sunday hundreds of men, women and children can be seen, ant-like, wending their way slowly to the top of this semi-active volcano, to view, first hand, the result of one of nature's most gigantic and spectacular mountain-building forces.

But Lassen Peak itself is but little more than a molehill on the side of a once mightier volcano—Brokeoff. The

Mt. Mazama, but every one that has visited Crater Lake in Oregon knows of this one-time mountain, for Crater Lake is in the crater of what was once Mt. Mazama. Both Brokeoff and Mazama, once towering peaks, have lost their proud heads by collapse, faulting and erosion.

Nothing is stable, least of all mighty mountains. Nature builds up a grand edifice, then before it is even completed starts its destruction. Witness the Grand Canyon as an example of just one of nature's destructive forces, erosion.



*Photograph by B. F. Loomis*

CRATER OF LASSEN PEAK ON NOVEMBER 10, 1914, AFTER THE FIRST SEASON OF ACTIVITY.

Lassen Peak Loop Highway winds its way up through the center and along the crumbling sides of this old Brokeoff crater. While it is not immediately apparent to the casual visitor that he is riding over what was once a seething cauldron of fire and "brimstone," nevertheless this is exactly the case, for the Brokeoff Volcano in its heyday was not only higher than Lassen Peak, but was responsible for the present height of the surrounding country for miles around.

The decline and fall of the Brokeoff monarch is much the same as the decadence of Mt. Mazama. No white man or Indian, so far as is known, ever saw

While Lassen Peak itself is not as spectacular in its present-day appearance as the public mind may believe—there is no yawning crater, no pit of boiling lava—yet clustered at the base of this mountain there are to be found six areas containing boiling pools of multi-colored acid waters; vents that hiss and roar deafeningly where live steam under tremendous pressure escapes from cracks in the ground; fascinating mud pots that build up small volcano-like cones or inspire awe with their deep-seated rumblings; small geyser-like fountains of boiling water and superheated steam. All this activity





ROUGH, JAGGED LAVA

THE NEWEST IN CONTINENTAL UNITED STATES—FORCED UP IN THE CRATER OF LASSEN PEAK IN 1915 IN A VISCOUS, MOLASSES-LIKE CONDITION. A RANGER IS STANDING IN THE LOWER RIGHT-HAND CORNER OF THE PHOTOGRAPH.

and heat, mingled with the ever-present clouds of sulfurous steam, give a weirdness to these areas and create an atmosphere of the supernatural and unreal. It is impossible to set down in cold print the thoughts and emotions that come to the visitor as he stands in the midst of all this turmoil and activity.

Even the names that have been given to these solfataric areas are indicative of their character—Sulphur Works, the Devil's Kitchen, Bumpas Hell, Steamboat Springs, the Boiling Lake, Terminal Geyser. The activity is similar to that found in the mud pots and hot pools of Yellowstone National Park.

In the naming of Bumpas Hell the story goes that an old miner, known as Bumpa, in the early days had the extreme audacity to flout the warnings of

nature and start digging for minerals on the very edge of one of these "hot areas." One day, while poking around among the fumaroles and steamers, the ground suddenly gave way and his foot went into a small pool of hot mud. Now, old-timers were not particularly careful about their language under such circumstances, and Bumpa was no exception. The spontaneous expletive that issued from the mouth of Mr. Bumpa on this occasion was henceforth attached to his name to designate this particular area—"Bumpas Hell."



LOOKING BACK

FROM THE LASSEN PEAK TRAIL, THE WINDING LASSEN PEAK LOOP HIGHWAY AND BEAUTIFUL LAKE HELEN PROVIDE A SIGHT LONG TO BE REMEMBERED.



THE SOUTHWEST ENTRANCE TO LASSEN VOLCANIC NATIONAL PARK IN THE SULPHUR WORKS AREA. LASSEN PEAK IS TO BE SEEN IN THE BACKGROUND DIRECTLY OVER THE NAME PLATE.

The Devil's Kitchen and Bumpas Hell are the two best known and largest of the park solfataras. The type of activity is similar, with only the elevation and setting different. Bumpas Hell is in a basin, about 10 acres in extent, on the rim of the old Brokeoff crater, and not over one mile from the southeast base of Lassen Peak. It is some 8,000 feet in elevation, and 1.3 miles by trail from the Lassen Peak Loop Highway.

The Devil's Kitchen is some 2,000 feet lower in the upper end of lovely Warner Valley. A dense growth of virgin fir,



THE WINDING TRAIL UP THE STEEP SIDES OF LASSEN PEAK.



BUMPAS HELL IN MID-WINTER.

THE WARM GROUND KEEPS THE DEEP SNOWS MELTED AWAY. AT THIS POINT AN AVERAGE SNOW DEPTH OF OVER 10 FEET (LEVEL GROUND) EXISTS ALL WINTER.

pine and cedar trees surrounds the area, while through the center of all the hot activity there flows a beautiful mountain stream of clear, cold, sparkling water. It is here that the fisherman seeking the unusual can catch a gamey rainbow or eastern brook trout, and, without removing it from the hook or moving a step, toss it into a boiling pool and thus cook his dinner! A small resort on private land exists within two miles of the Devil's Kitchen and half a mile from the Boiling Lake. Deer graze in great numbers on the meadows near this resort, while horseback riding, swimming, fishing, hiking and other

original vent in the old Brokeoff crater from which lava flowed and built up the overhanging cliffs of Brokeoff Mountain to their present height of 9,200 feet. This and other activity in the old crater suggest that fires still smoulder far beneath the surface and that some day a renewal of the old-time volcanism may occur.

Returning again to the somewhat fascinating question of possible future activity, the U. S. Geological Survey maintains an observation at Mineral. A resident volcanologist, R. H. Finch, resides here the year around and operates the observatory instruments.



A GURGLING MUD POT IN BUMPAS HELL.

MAKING MUD PIES WAS NEVER AS FASCINATING AS WATCHING THESE LAZY BUBBLES RISE AND BURST.

forms of recreation attract many visitors during the pleasant summer months.

One of these "hot areas" can be seen by automobile; in fact, the Lassen Peak Loop Highway runs within 100 yards of several active steam vents, fumaroles and boiling pools. This area, the Sulphur Works, is particularly interesting, because it is given by Professor Williams<sup>3</sup> as being the exact spot of the

<sup>3</sup> H. Williams, "Geology of the Lassen Volcanic National Park, California," *Bull. Dept. of Geol. Sci., Univ. of Calif.*, Vol. 21, No. 8, p. 244.

Three seismographs are operated by the Survey at Mineral and in the park. They are arranged in a triangle around Lassen Peak, one to the north of Manzanita Lake, one to the south at Mineral, and the third, southeast of Lassen on Mt. Harkness. The seismograph at Manzanita Lake is located in a separate building in front of the museum, and visitors find it very interesting to stand and watch this delicate instrument at work. A ranger-naturalist is usually stationed at the museum who operates



LASSEN PEAK LOOP HIGHWAY  
WHICH CIRCLES AROUND AND PASSES RIGHT BY  
THE GROUP OF STEAM VENTS IN THE SULPHUR  
WORKS AREA, ONE OF WHICH IS SEEN HERE.

the instrument and is on hand to explain it and the other exhibits at this point.

During the first year of operation of the Mineral seismograph (1927) a total of 266 earthquakes were recorded on the smoked paper. Last summer (1933) over the 4th of July holidays no less than 34 distinct shocks were recorded on



TWO HUMAN FACES  
FORMED ON THE 1915 LAVA IN THE CRATER OF  
LASSEN PEAK. CLOSE INSPECTION OF THE PHOTOGRAPH WILL REVEAL TWO MEN AT THE BASE OF  
THE UPPERMOST FACE.

this delicate instrument. While all the earthquakes felt here in recent years have been comparatively light, it nevertheless indicates that activity of some sort is going on in this region which may some day again startle the world.

But Mr. Finch has confidence that his instruments will tell him in advance of any future eruptions. He places his confidence chiefly on the small tilt-recording apparatus that is attached to the seismograph. It seems that the whole Lassen edifice is constantly rising and lowering; that is, tilting in one direction or another. This is due to the increase or decrease in pressure beneath the surface. The tilt-recording instruments tell the direction of this tilt and the amount.

Should the pressure beneath the surface become unusually great, it follows that this increase in pressure would tend to increase the tilt, which would in turn be recorded and noted on the seismograph, and predictions made accordingly on the possibility of an eruption. While Mr. Finch declines to state if, and when, Lassen will again erupt, nevertheless both he and the author see to it that they keep plenty of photographic plates on hand and ready for use!

Generally, Lassen Volcanic National Park, as far as its natural features are concerned, can be divided into two parts. The western half of the park is rugged, wild and spectacular in its jagged, alpine-like crags and peaks. Much of it is above timber line. In the silent, lonely winter months these crags rise above the glistening white snow fields in a striking similarity to the Swiss Alps.

While the western half is breathtaking and awe-inspiring, the eastern half, in direct contrast, is soothing in its effect. Innumerable gem-like lakes lie undiscovered in the extensive forests of pine, fir, hemlock and cedar. Flowing streams may be seen at the foot of rolling hills. An atmosphere of peace and calm prevails over the area. But exceptions exist here and there. One will



## LAKE EMERALD,

NESTLED AT THE FOOT OF LASSEN PEAK. THOUSANDS OF HUNGRY RAINBOW TROUT LIVE IN THE LAKE AND VISITORS GREATLY ENJOY FEEDING THESE BEAUTIFUL FISH. IT IS A NATURAL AQUARIUM.



LASSEN PEAK AS IT LOOKS TO-DAY FROM ACROSS MANZANITA LAKE.





KINGS CREEK FALLS



suddenly come upon a jet-black, barren lava flow; a spire of lava will rise above the timbered slopes; a cinder-cone-topped extinct volcano will invite inspection.

Such is the unexpected sight that presents itself to the visitor entering the northeast corner of the park. Surrounded by a forest of huge jeffrey pines, the trees abruptly stop and a wall of new, black lava rises from the sandy soil material. It is the lava flow from the Cinder Cone.

To write about the Cinder Cone, to try to describe it, is to depreciate its spiritual beauty. The Cinder Cone is a sight to be viewed in silent awe and appreciation. The cold facts are that the cone is 660 feet high, half a mile in diameter at its base, is in absolutely perfect symmetry and proportion, has a double crater in its peak, devoid of vegetation, dark-colored and made up entirely of small rock-like cinders. It is skirted on one side by the timbered slopes of Prospect Peak, and on the other side by a flat, undulating, fan-shaped field of jagged black quartz-basalt lava, the last flow of which occurred only 84 years ago.\* Part of this flow is covered with a highly colored ash, known as the Chromatic Dunes; in all, a remarkable sight.

Snag Lake and Butte Lake, east of the Cinder Cone, were at one time one large lake. As recently as 300 years ago, lava flows from the base of the Cinder Cone flowed into this large lake, forming the two lakes named above. And now it is a strange sight to see this wall of black broken-up lava blocks extending out into the lakes, particularly as the opposite shore of both Butte and Snag Lakes are well timbered and diametrically opposite in appearance to the barren lava wall.

To add to the peculiarity of the area, the eruptions from Cinder Cone spread a sandy layer of volcanic ash, several

\*Finch and Anderson, *Bull. Dept. of Geol. Sci., Univ. of Calif.*, Vol. 19, No. 10, 1930.

feet thick, over fully 30 square miles of area. The majestic pines grow up through this sandy ash in a park-like stand, most beautiful to look upon. But woe betide the careless motorist who allows his car wheels to leave the two firm tracks and sink down in the loose, soft ash, for verily he will have much pushing and puffing to get back on solid ground.

As yet no paved roads have been constructed into Butte Lake; in fact, the park administration is debating the question, whether or not to keep this area undeveloped and unspoiled by crowds of visitors. There is a constant demand for more and better roads, but



NIP, BROTHER OF TUCK,

SPECIAL ASSISTANT TO THE RANGER AT MANZANITA LAKE CHECKING STATION AT HIS JOB OF WELCOMING VISITORS TO LASSEN PARK. NIP IS A SIERRA NEVADA GOLDEN MANTLED GROUND SQUIRREL WHO GOES BY THE IMPOSING NAME OF *CALLOSPERMOPHILUS CHRYSODEIRUS CHRYSODEIRUS* (MERRIAM).

there is also a demand for the wilderness area from that type of person who loves to get away from the crowd and enjoy nature alone or with his own little group. Butte Lake and the Cinder Cone, however, are at present only an hour and a half drive from the nearest highway, and the inconvenience of the dirt road is compensated by the beauty and interesting phenomena to be found there.

Geologically, Lassen Volcanic Na-



#### CRESCENT CRATER

DOZENS OF VOLCANIC MOUNTAINS AND CRATERS EXIST IN THE PARK. CRESCENT CRATER OCCURRED ON THE NORTH SLOPES OF LASSEN PEAK, SHOWN ON THE EXTREME RIGHT. AN IDEA OF THE DENSELY FORESTED TYPE OF COUNTRY CAN BE GAINED FROM THE TIMBERED FOREGROUND. THIS FOREST ORIGINALLY EXTENDED TO CRESCENT CRATER. THE 1915 ERUPTIONS, HOWEVER, DENUED THE COUNTRY SHOWN IN THE PHOTOGRAPH AS BARREN AND FORMED WHAT IS NOW KNOWN AS THE DEVASTATED AREA.

tional Park is important for its recent volcanic activity. Geographically, this area marks the southern end of the Cascade Range. It is actually on the extreme southern tip of the volcanic platform of that range and less than 30 miles from the granitic Sierra Nevada. Biologically, the flora and fauna are not only plentiful, beautiful to the eye and abundant in recreational attributes, but also important to the botanist because here are found many hybrid species having characteristics of both the Sierra and Cascade plant life.

The area, up to the present, has been inaccessible except by trail and a few inferior roads. It was not until 1925 that the National Park Service first began active administration and development of the park. Since that time, work has been quietly but diligently carried on by building roads and trails, developing camping areas, constructing buildings, placing signs and otherwise opening up and developing the park for

the numbers of visitors that will soon be coming to marvel at and enjoy the recreational, scenic, volcanic and geologic features found here in such abundance.

While Lassen Peak and the interesting volcanic exhibits are the first attractions to the public, it has been found that the fishing, hiking, camping and boating and the wonderful forests, innumerable lakes and streams, lovely high mountain meadows, birds, chipmunks, deer and other wild animals, the scenic drives and all the factors that make for enjoyable vacations in the mountains are what bring the visitors back to the park year after year. And now that accommodations at Manzanita Lake, Warner Valley and Juniper Lake are available, no longer will it be necessary for the visitor to camp out or hurry through in one day.

Lassen Volcanic National Park, truly a gem in a little known country, ranks with its older national park brothers as an area of which we can be justly proud.

# WORLD POPULATION

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## I

So much has been said and written of late years on this subject that one may seem presumptuous to add more words to the discussion, but the present writer feels that the point of view of the geographer has not been adequately presented, in this country at least. The public has been entertained, puzzled and even alarmed by such books as Ross's "Standing Room Only," East's "Mankind at the Crossroads," Pearl's "Biology of Population Growth" and Stoddard's "The Rising Tide of Color."

According to East:

The facts of population growth and the facts of agricultural economics pointed severally to the definite conclusion that the world confronts the fulfilment of the Malthusian prediction here and now. Man stands today at the parting of the ways, with the choice of controlling his own destiny or of being tossed about until the end of time by the blind forces of the environment in which he finds himself.<sup>1</sup>

Mankind did not give this subject serious thought until the publication of Malthus's classic work on this theme. Since that date there have not been wanting writers who have liked to indulge in Cassandra-like prophecies of doom. We have had them in nearly every field of thought, and still the old world wags along and our raw materials have not become exhausted, our population continues to increase and civilization still endures. The same fault vitiates all these gloomy predictions. All these prophets of doom have lacked perspective.

In this paper the writer will attempt to criticize and synthesize some of the existing data on this subject of population, and bring to bear the point of view and information of the geographers and

take issue with the biologists, journalists and novelists. At the outset it may be stated very definitely that there appears to be no reason for pessimism, nor for undue optimism. The writer's first thesis is that this subject is primarily a geographical one. This is readily proved by a mere enumeration of the factors controlling population, to which we shall return in subsequent paragraphs.

Certain books of comparatively recent date have been mentioned, but the reader's attention should be called to some other works if he is going to approach this subject with any degree of scientific accuracy. The "Proceedings of the World Population Conference" (Geneva, 1929) is a most important contribution. However, even this first great world conference on the subject had serious shortcomings, since in an assemblage of 123 delegates of economists, statisticians and biologists, only one lone geographer was present.

"Population Problems," by Warren S. Thompson, is the best general book on this subject in English with which the writer is acquainted. This book refers primarily to United States problems and especially to such subordinate topics as rural *vs.* urban and occupational aspects, with which we can not concern ourselves in this paper.

Another important contribution to the subject, especially of a statistical nature, is Kuczinski's analysis under the title, "The Balance of Births and Deaths." Dr. L. S. Cressman, of the department of sociology, University of Oregon, has made a brief abstract of this paper for the present purpose, since it lies in his field of statistics. Quoting his statement:

The changing age composition of the different populations of the world has a marked effect

<sup>1</sup> East, "Mankind at the Crossroads," Preface, p. 8.

on the birth and death rates. Improvements in health and sanitation have reduced the deaths of infants and children so that now we have a larger proportion of the population in the middle age groups, or the age classes marked by low mortality. In addition to this, the birth rate has been reduced by the use of contraceptive devices. The birth rate per 1,000 population would seem to be likely to increase for a time in view of the changing age composition, but on the other hand, birth limitation reduces the rate of births. The difference between the decreased death rate and the birth rate will not be so great in view of contraceptive techniques. But with the reduced proportion of children in the population eventually a time will be reached when there will be an excess of aged people, so that the death rate will increase for a time. Time will correct this, and probably the result will be, as in France, a stationary population. This does not apply, however, to great masses of the world's population at the present time.

The present writer has no intention of questioning Kuczinski's conclusions. He is not here attempting to settle the problem of the world's actual population, but the larger and perhaps more important aspect, namely, the world's possible population under the most favorable conditions. Of course, at the present time, during the world's most serious depression in modern times, we see population growth severely retarded in many countries, especially in those like our own where industrialism is so important. It may be that such checks as these and those produced by floods, famines, war and disease will always remove the danger of over-population.<sup>2</sup>

In the writer's own treatment of this subject, he will draw heavily upon four sources of information and interpretation: First of all, there is the well-known professor of geography at the University of Berlin, Albrecht Penck, who has taken the lead in this subject

<sup>2</sup> A very recent and exceedingly important report of the Second General Assembly of the International Union for the Scientific Investigation of Population Problems, held at the Royal Society of Arts, London, from June 15 to 18, 1931, has been referred to in *Nature*. The present writer regrets he has not had access to this report.

abroad. The writer had the great privilege of being a member of Professor Penck's seminar on this subject at the University of California a few years ago. Second, Professor Griffith Taylor, formerly of Sydney, Australia, now of the University of Chicago, whose book "Race and Environment" is one of the standard works in geography. And third, the publication resulting from the Geneva Conference. Finally, the writer will draw upon his own observations in many parts of the world extending over a period of twenty-five years of travel. Many loose statements of certain publicists to-day can be properly checked only by observations on the ground.

Let me hasten to state that the writer does not regard himself as infallible in this field, and many of his statements are tentative. The vastness and complexity of the problem should cause any one, particularly a scientist, to be cautious and reserved.

## II

A rapid survey of the factors controlling population will reveal both the intricacy of the problem and at the same time the compelling need for some humility in attempts properly to appraise it, to say nothing of trying to solve it.

The primary factors as usually given are: natality, mortality and migration. It is obvious that the rates of birth and death and their ratio and the shifting of peoples from one region to another are the primary factors in population, and no one would question the part played by the secondary factors, climate, food, shelter and power resources in influencing the first named, though each of us might weight these effects differently.

The writer does not propose to spend much time on these points, as they have been discussed by all those who have pretended to any serious study of the subject. He will, however, call attention to some other factors and considera-

tions that have not always received adequate attention.

The effects of light and barometric pressure as a part of climate should be touched upon for a moment. We have as yet too little data on which to base much that is conclusive in this field. Some years ago the late Dr. Woodruff of the United States Army made quite a study, though inconclusive, with reference to the effects of tropical light, particularly on white men, and came to the conclusion that light in the tropics was a serious factor in the population of tropical regions by men who were not sufficiently supplied with pigment in the skin. Probably both excessive light and low barometer affect not only man's well-being in the tropics, but also his fecundity. On this last point the writer knows of no data. He merely calls attention to an interesting subject for research.

The biggest factors to-day, probably in this whole question, are science and invention in modifying our climates or offsetting the effects of climate and food shortage. In the beginning Pearl's

studies on population growth were referred to. Pearl studied the rate of growth of *Drosophila*, a fruit-fly, in cultures of a definite amount of food and found that their multiplication followed a definite curve, the so-called logistic curve (Fig. 1) and drew the analogy between the fruit-flies' growth and that of human beings. This would be very well if human beings were confined in a large bottle and had no access to any other food than what was supplied to them in this bottle. And human beings in certain localities have had a growth curve which was remarkably like this curve, but in several instances this normal growth curve has been interrupted and the growth increased due to some change in that locality whereby more people could be supported, and the curve has again ascended. The food supply was not fixed, that is to say, this is a variable, and furthermore food supply depends upon other variables.

At this point attention should be directed to this danger of using formulae and trying to express such matters by means of mathematical terms. This is

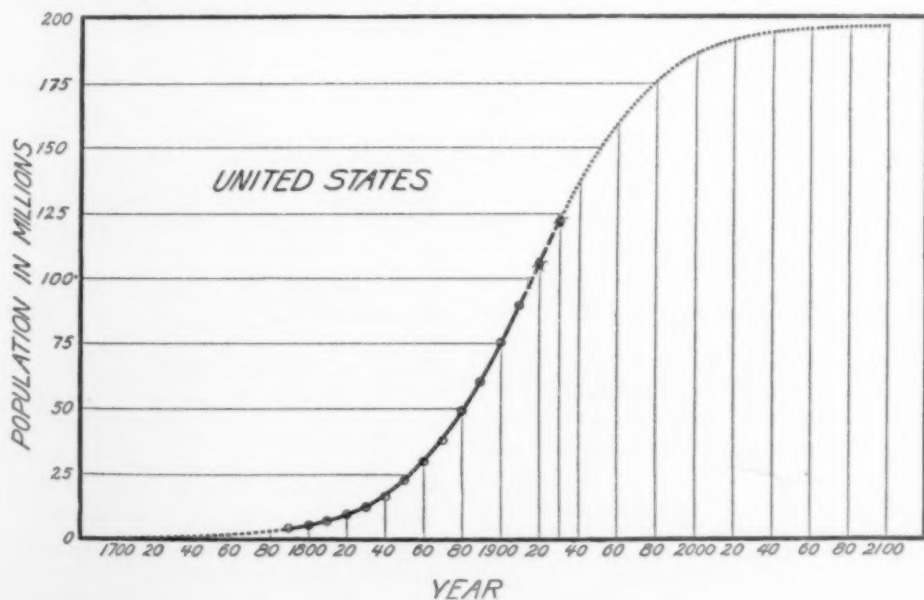


FIG. 1



all right if one knows all the factors and just how to weight each one. It is quite proper for the biologist and statistician to attempt to do this thing, but he must be very careful not to jump to conclusions on the basis of such expression, and several European scientists have taken Pearl to task for this very thing.

On this subject Wilson and Puffer say:

If by the statement that the logistic, whether augmented or not, is the law of population growth, one means only that the formula is well suited to fitting the census enumerations for the period of a century or so when such enumerations have actually been made, we can take no exception to it, for we have shown that those enumerations can be fitted even more closely than they have been fitted by others. But if the statement is to be considered as signifying that the formula affords a rational law to such an extent as to permit the extrapolation of the curve for forecasting purposes and the interpretation of the constants as constants of nature, we are forced to take serious exception to it, because we find that there are too many instances in which the curve becomes infinite in finite time or has a negative lower asymptote or both and because the constants are too often so poorly determined as to be practically undetermined; in all these cases we must at least withhold judgment until the populations have developed so far toward saturation that the fitting of the curve will give reasonably well determined indications of the saturation values.<sup>3</sup>

Five very important factors, for which science is in part responsible, have changed the complexion of this entire problem of population, and to these we would direct your attention now. They are: (1) Irrigation and improved agriculture. (2) The preservation of food by canning, refrigeration and desiccation. (3) Transportation of food, as well as human beings, from one place to another. (4) Conquest of disease and improvement of health in man. (5) Conquest of disease in crops and animals.

<sup>3</sup> *Proceedings of the American Academy of Arts and Sciences*, Vol. 68, No. 9, August, 1933—Edwin B. Wilson and Ruth R. Puffer, "Least Squares and Laws of Population Growth," p. 340.

The first, irrigation, is of course an ancient practise, but modern science has enormously increased the effectiveness of it. The improvements in agricultural practise, particularly in the direction of mass-production, has to-day given us more food actually than we can consume.

Man is growing wheat much faster than he is eating it, so that much of the present distress in agriculture is due to an evil long familiar to manufacturing—simple overproduction. This was the thesis of an address by G. V. Jacks, of the staff of the Rothamsted Experimental Station, delivered before the British Association. During the last twenty years the world's wheat area has been increased by over 20 per cent., and production by over 25 per cent.; the increase in population over the same period has probably not been more than 14 per cent. The causes of this overproduction have been very complicated, and are hard to analyze; but economic, scientific and political factors have all played their parts.

Similarly, through our ability to can, freeze and dry food we have eliminated famines in those regions where these practises are carried on. One scientist, Free, has said that in his opinion the canning of food is perhaps the greatest scientific discovery man has made.

Think of what it will mean to the undernourished millions of Asia when we transport to them millions of gallons of fresh frozen milk, as we are beginning to do.

In the conquest of disease and in the improvement of public health, we have another potent factor, the full import of which we are just beginning to learn. The reader is invited to read the romance of the American doctor and sanitary expert in the one restricted field of the Philippine Islands alone. The change wrought in that archipelago reads almost like a tale out of the Arabian Nights. The famines of China and India need not occur at all to-day



and will, in time, become a matter entirely of the long-forgotten past. There is enough knowledge and skill and food available in those lands to banish these terrible scourges if men there could be made to change their age-old practises.

In our survey of the world to which we shall next turn we shall have always to consider density of population. Let us analyze this. First, we shall use a formula derived by Penck, not necessarily to prove something, but in order to clarify the discussion. Perhaps we

Pacific Coast there can be no other topic quite so relevant to our situation.

In our regional survey the writer will make use of Köppen's classification of climate, since climate is perhaps the most important single geographic factor affecting population. Again, we are indebted to a German geographer<sup>5</sup> for guidance in our attack upon this problem.

It should be understood at the outset that these estimates can be *tentative* only. Space does not permit the writer

$$\text{Density of Population} = \frac{\text{Natural Productive Power} \times \text{intensity of Production of Region}}{\text{Need for production (food)}}$$

or using symbols:      Wherein d equals density of Population  

$$d = \frac{Ki}{n}$$
                                     K equals Productive power  
                                     i equals intensity of production  
                                     n equals need

may have to change this formula somewhat or even get a new one entirely. As it is, perhaps, the best available at present, we shall use it. Productive power (K) of a region is dependent upon *climate* and *soil*. Intensity of production depends largely upon character of people, that is *race*. Need for production depends upon a number of things, density principally and geographical situation.

## III

This made clear, we shall now carry out a rapid survey of the world's natural regions, using the salient facts of climate, soil, race and present population, and attempt to arrive at an estimate of possible future population saturation following Penck.<sup>4</sup> And finally, when this has been done, we shall devote some little time to a consideration of the, to us, all-important sub-topic, the expansion of the white race, to which Griffith Taylor has devoted so much research. To us on the

to give all the details of the discussion necessary to arrive at the following figures. Briefly the method entailed a close scrutiny of all the factors affecting population growth in each climatic region and a comparison with regions wherein conditions were as nearly as possible ideal and a consideration of every militating factor. Of course biologists and geographers would emphasize these differently, and perhaps no two men in the same field would weight these alike. It may be said, however, that in Professor Penck's seminar where this survey was made the group of about a dozen students, chiefly professors or advanced research workers, collectively had personal first-hand knowledge of practically every climatic region of the globe.

(1) Beginning with the *Tropical Rain Forest* (Af and Am Köppen) you will note on the chart the limits of this region. This comprises about one tenth of the land area of the world, or 5,400,000 square miles. During no month herein does the mean temperature fall below 64° (18° C.) while the precipita-

<sup>4</sup> Albrecht Penck, "Das Hauptproblem der Physischen Anthropogeographie," *Zeitschrift für Geopolitik*, Heft 5, Jahrgang 2, 1925.

<sup>5</sup> W. Köppen, "Grundriss der Klimakunde."

CLIMATES OF THE EARTH

W. KÖPPEN, 1907

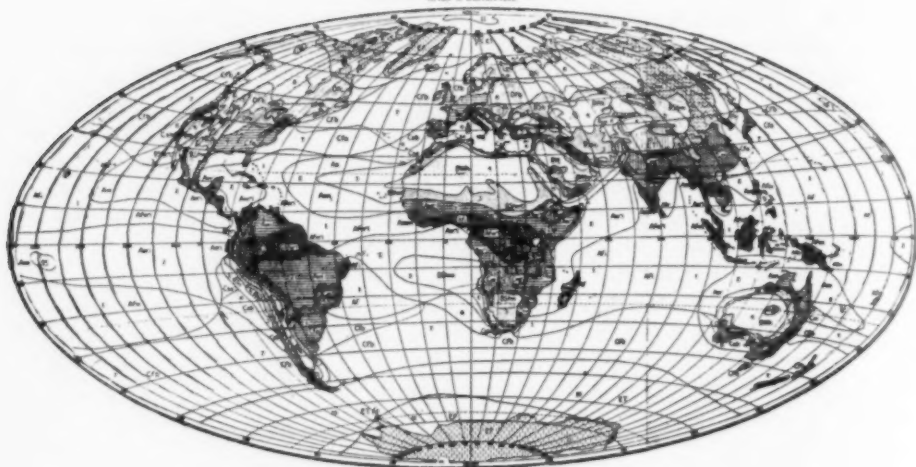


Fig. 2

tion in the driest month is in excess of  $2\frac{1}{2}$  inches. Over much of this area deep, rich volcanic soils prevail, and the vegetation covering is exceedingly luxuriant (Fig. 2).

The island of Java gives us the clue to population possibilities in this part of the world. Although the island is by no means a plains country, there being many volcanic mountains and rugged terrain, the population here is about 500 per square mile. On the basis of this a possible total population has been estimated by Penck at 2,800,000,000. Personally, the writer subscribes to somewhat less and places his figures at two billion. Even so, this is almost equal to the present total world population, which is estimated at about 2,024,286,000. The reason for cutting off some 800,000,000 from Penck's estimate is that it is extremely doubtful whether the intense land cultivation in use in Java could ever be duplicated in the remainder of the equatorial belt. Rich soil, an energetic, highly intelligent kind of people driven by the Dutch colonial system have all combined here to produce a remarkable result.

As a food reservoir this region will, in

the opinion of the writer, in time, if not now, be more important than mesothermal (temperate) regions.

(2) *Tropical Savanna region (aw Köppen)*: This climatic region has a distinct dry season with .24" in the driest month and no month with a mean temperature below  $64^{\circ}$  ( $18^{\circ}$  C.). The Madras Residency in India is a typical example. There are approximately 6,300,000 square miles of available land in the tropical savannas. In the Madras Residency there are about 225 persons per square mile.

Two other great areas can be further populated, the Deccan of India and the Matto Grosso in Brazil.

On the basis of these figures it has been estimated that 1,413,000,000 total population is possible in the tropical grasslands of the world. Here again, we would trim these figures down to one billion, since we do not believe that the same density of population can be maintained in these areas outside of India. The advantage in India lies partly in the English over-lordship and partly in the people themselves.

(3) *Dry Climate Regions (B—Climates of Köppen)*: Here we must con-

sider two sub-regions, the deserts (B-W Köppen) and the Steppes (B-S Köppen).

In the deserts, of which central Asia and the Sahara are typical examples, the range of temperature is from 33°-117° F. (1°-47° C.), while precipitation varies between 2" and 5" per annum.

The population is about .25 per square mile, and the total areas of all such regions will come to something like 11,000,000 square miles. Penck estimates 18,000,000 as the possible number of people who could be supported. Of course this presupposes much more efficient living than one finds in most of these regions to-day. But this is not at all unreasonable to expect with the advance of modern knowledge into such areas.

We have been reading a most illuminating book recently, "The Mysterious Sahara," by Prorok, which reveals the great wealth of cities that once existed in that forbidding territory, and it appears scarcely possible that change of climate is solely responsible for the depopulation there. It is highly probable that wars, disease and racial decay have been quite as potent factors in this remarkable eclipsing of those ancient civilizations. On the other hand, if we follow Huntington, we must lay the chief blame upon change of climate. We can not, in the light of present knowledge, be too positive in our conclusions.

In the steppes, of which the lands contiguous to the River Don of southern Russia are an example, the temperature range is between 82° and 97° F. (28°-36° C.) with a precipitation of 14.5" per annum and 2" the greatest amount in one month.

At present the population runs about twelve per square mile, and there are 13,200,000 square miles of such lands. The total population estimated for the steppe land is 106,000,000. What the ultimate possibilities of these regions can be largely depends upon the present experiments on the part of the Russians.

(4) *Mesothermal Climates* (C—*Climates of Köppen*): Here again we have two subdivisions to consider, a moist temperate and a dry temperate.

The mesothermal climatic regions are for the white man, and for all but the black race, and for world civilization the most important.

The moist temperate climatic province can be further subdivided into a region wherein the winters are moist like China and western Europe, and a second region like Bengal where the winters are dry. We might even consider eastern Asia as distinct from western Europe and the United States because of its distinct Monsoon climate which has its own climatic peculiarities.

In the first-named region the precipitation varies from 20"-57" and the temperature from 27°-66° F. (3°-18° C.).

At present the population density is placed at 250 per square mile, and the total area is 37,000,000 square miles.

If China and Russia and parts of South America become industrialized to a degree approaching that of Western Europe and certain waste lands in China be reclaimed, this vast area ought to support a prodigious population. This of course will depend to some extent upon certain economic adjustments, perhaps like those now on trial in Russia.

Penck concludes that this first subdivision can support 930,000,000 people, or one half the total for the globe at present.

Think for a moment what this means for the people of Europe and America. It is fairly plain that we probably can not maintain our material standard of living and still adhere to a ruthless competitive system. As much as we may wish to, we can not resist inevitable changes in our social and economic structures.

It behooves us to say just a word concerning standards of living. The tariff boosters particularly lay great stress upon the "American standard of living," meaning by this plenty of bath-

tubs (and one or more baths a day, which of course is not necessary outside the tropics) motor cars, white flour bread, etc. Nothing is said about the low level of this sort of emphasis upon creature comforts. Perhaps it does not enter the head of the Senator from Utah that perhaps the lowly Japanese with his flower gardens and temples and philosophy of jiu-jitsu may actually have a higher standard of living than an American movie star.

In the Bengal type of region, warm and with dry winters, the range of temperature is from  $32^{\circ}$  to  $116^{\circ}$ —hot rainy summers, with a precipitation of 25". Here the population density is 228 per square mile and 8,000,000 square miles all told.

Assuming that this density can not be maintained for the entire area, but only one half of it, we would have about 900,000,000. Penck's estimated population for this region is 1,243,000,000.

For the dry temperate, California, the Mediterranean and central Chile, we have the following figures: Temperature,  $32^{\circ}$  to  $64^{\circ}$  for the mean range; precipitation in winter 17.6"; population density, 125 to 250 per square mile, 225,000,000 total population estimated.

Much of this region, like Italy, has 250 per square mile, and the Los Angeles area a great deal more, and if we calculate upon a basis of 1,500,000 square miles total area, and 150 per square mile, we can easily reach the estimated total given above. The writer would be inclined to divide this by at least two, because of mountainous and other types of relatively waste land.

(5) *Microthermal Climates (D—Climates of Köppen)*: These are the cool temperate climates, and we may subdivide them into two—the winter dry type exemplified by northeast Siberia and the winter moist type exemplified by Canada and western Siberia.

In the first subdivision we have a range of temperature from  $58^{\circ}$  to  $-90^{\circ}$

F. ( $15^{\circ}$  to  $50^{\circ}$  C.), the extremely low temperature being recorded at Werchojansk, Siberia. The precipitation averages about 5".

Penck believes that this region could support 75 per square mile, but hardly under present conditions. This would give close to 200,000,000 population. A great deal of drainage would have to be resorted to in order to make these lands suitable for cultivation, but this is not an insurmountable obstacle.

In the second subdivision the range of temperature is not so great, nor do we have such extremely low temperature and the precipitation is about 21".

With an estimated area of 15,000,000 square miles it is thought that 735,000,000 people might be supported, but of course this is a long time in the future. Since the writer's recent trip through Alaska and the Yukon territory, he is inclined to reduce Penck's estimates considerably and divide his figures by two or even three, let us say then 300,000,000 only.

(6) *Tundra Climates (E—Climates of Köppen)*: In regions having tundra climates the temperature in the warmest month varies from  $32^{\circ}$  to  $50^{\circ}$  F. There is a slight summer precipitation.

Such regions as the Arctic, of course, will never support many people, and all told they will never amount in the aggregate to more than a half million, in all probability. In spite of Stefansson's optimism the "Friendly Arctic" will doubtless never prove to be a reality. Even according to his own experiences it can hardly be so described, since it is reported that eleven men died on his last expedition into that region.

The real value of the Polar regions is not as habitats for man, but as producers of food. Shipping of reindeer meat to the United States and Europe to-day indicates what this may amount to.

(7) *Climates of Perpetual Frost (F—Climates of Köppen)*: Examples of these are Greenland, Antarctica and the

Himalayas. The population for these is practically nil.

If we sum up all these regions, we have a grand total of 5,666,000,000 as against 2,024,286,000<sup>6</sup> present world estimated population. Penck's total estimated possible world population is 7,689,000,000.

It is of course quite improbable that the world population will ever reach the stupendous total estimated in the above paragraphs. Wars, diseases, the natural curbing of the birth rate with the shifting of civilization from an agricultural to an industrial basis, to say nothing of the operation of birth control and birth selection, which will probably be practised much more in the future than in the past, will tend to keep the population more or less static in many parts of the world, as it is to-day apparently in France. An attempt has been made here to show the number of people that the earth might support, to bring out how complex the whole subject is, and to emphasize that a true appraisal can not be arrived at by any one group of specialists alone.

#### IV

One of the related problems which is suggested by this study is for us of extreme importance, and that is, where will the white races go? On this subject Professor Griffith Taylor has given us some very interesting discussions in his book on "Race and Environment."

Now, the white race is limited by climatic factors quite definitely, or has been in the past, and also by certain economic factors. Taylor asserts, and we believe with good reason, that these "controls" are (1) Altitude, (2) Temperature, (3) Precipitation and (4) Coal. In the larger world picture coal

<sup>6</sup> This latest estimate of the number of human beings in the world that has come to the writer's notice is made by Professor A. M. Carr-Saunders, of Liverpool University, who states that the number is increasing about twenty million a year.

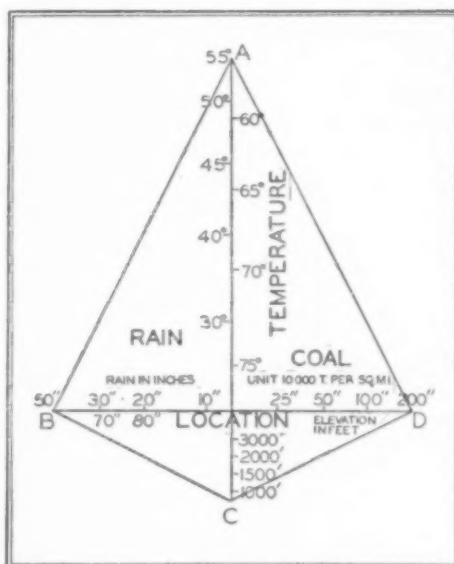


Fig. 3

far outweighs in importance wood and water as a source of power.

He has worked out on the basis of these a very expressive "econograph" which, in the case of the ideal conditions which he sets up, resembles the frame of our old-time American kite, as indicated in the diagram (Fig. 3).

Here we have, according to his scheme:

Rainfall (or snow) .....	50"
Temperature .....	55°
Elevation .....	sea-level
Coal .....	200 × 10 <sup>4</sup> tons per sq. mile

From these he computes an ideal econograph with 1,000 units as the maximum and thus surveys the world to see how each political subdivision fulfils these conditions. It is interesting that the British Isles and North China come nearest, with 770 units each, to reaching the ideal. The northeastern United States comes second with 755 units, and the interior plains of North America third with 675.

The writer would modify Taylor's econograph in several details. First, he



would extend the altitude limits to 1,000 feet above sea-level, since many of the world's large agglomerations of people are found well above sea-level, but relatively few above 1,000 feet.

While 55° may be the optimum temperature, large populations of white people are found living at a somewhat higher average temperature, though not much above this. This figure might easily be raised to 60° without much loss to either physical or mental efficiency.

50" of rainfall requirement is also unnecessarily high, and I would consider 40" as sufficient, since a foot of controlled water is worth as much as three feet of flood water, and the use of water in the future will be more and more controlled and conserved.

Likewise with advances in technology, electricity from water power will more and more supplant the use of coal, so I would allow for that in my estimates of power resources.

These modifications somewhat alter the picture of white race expansion. Under Taylor's scheme the white race with its particular industrial civilization is pretty definitely limited. Into certain desirable regions like eastern Asia it can not go because these are preempted by peoples we can not compete with on any terms. Into other regions like the Tropics we can not go, according to Taylor and Huntington, because of climate.

With Taylor's conclusions Penck and the writer do not agree altogether. Under pressure of population and need for economic exploitation the white race will be forced to expand beyond its present habitat, and indeed at the present is doing so. In fact, it has done it in the past. The so-called Aryan branch of the white race moved very slowly in the past down into India and occupied a sub-tropical region, even though in doing so it became dark-pigmented.

In South America they have moved into another sub-tropical region, Brazil,

and are living there very successfully. In two other regions they are now advancing slowly into the Tropics, from southeastern Australia into Queensland and in Africa from South Africa into east Central Africa, very slowly it is true, but doing it. The important thing is that it is being done *slowly*. We have heard much of the effect of the tropics upon the white man. On this point the late Colonel Woodruff, U. S. A., was very emphatic in saying that white men could not live permanently in the Tropics. In this the writer is in very emphatic disagreement with his findings. Of course if one goes abruptly, suddenly from a temperate region into the Tropics the effects are bad, but if the race takes it slowly, many generations, it can be done, is being done and has been done.

One very interesting and extremely important point in this connection made by Penck is that these great movements of whites into Subtropical and Tropical regions are by way of *east coasts* at the present time. Rainfall and tempering sea breezes are here the chief factors. An important consideration here is the fact of miscegenation attendant upon these migrations.

Two other points must come up for consideration in this expansion of the white race, namely, fecundity and birth selection. It has been shown that the darker races breed faster, but the whites bring up more children. Furthermore, in the intense competition of the present and the future, birth selection will play a greater and more important rôle than in the past.

On this point East says:

If the human race really desires a continued progress, a fair chance, a longer and happier life for every individual, the birthrate must come down faster and faster; and it must come down throughout the whole population and not merely within one section which furnishes those of greatest social worth. To accomplish this, parentage must not be haphazard.



Intelligent persons not wholly swayed by irrational tradition and emotional prejudice will be disposed to accept the idea of rational parentage as wholesome and proper. At the same time one should be under no illusion as to what is likely to be the immediate fate of a social scheme which requires an appreciative forethought by whole peoples, and not merely acceptance by the intelligentsia. No matter how much suffering could be prevented, no matter how much greater a civilization could be built by its application, its general adoption will probably await the compelling force of economic necessity. What else could be expected? Half the people in the world lack sufficient brains to cope with the intricate system of social life the industrial age has brought about. Half the remainder are without the proper training; they lack the power of knowledge. The remaining quarter, who might worthily direct the great majority, sit complacently as long as they are permitted to take an extra toll of the good things of life, and watch the direct control of the destinies of nations remain in the hands of those whose chief claim to the honor is the ability to emit those hollow words which fill *The Congressional Record* and the parliamentary debates. Knowledge is not wisdom. Knowledge to prevent the decay of our social fabric is not wanting; but it is a serious question whether there is the required amount of that type of ability which will make a sustained effort to apply it.<sup>7</sup>

The darker races are beginning to practise birth control, but it is doubtful if they have as yet learned much about the more important thing of birth selection. Japan is a notable exception to this statement.

On this subject we would like to make the observation that of the two, birth control and birth selection, the latter is much more to be desired, and it is imperative for all nations to take some steps in this direction. These matters can not longer be decided on religious or sentimental grounds. It is much safer for us here to follow the lead of the social scientists.

Let us turn to Osborn on this subject:

With such principles in mind, and with the picture before me, of the world suffering acutely from dysgenic reproduction, from the multipli-

<sup>7</sup> Edward M. East, "Mankind at the Crossroads," p. 350, ch. 12.

cation of the incompetent, and from the alarming increase in the power of the criminal class, I can not refrain from expressing my deep conviction that, of all remedial and restorative agencies, the well-understood and well-applied principles of birth selection advocated by Galton, with birth control as a subsidiary principle, stand in the very front rank of progressive civilization.<sup>8</sup>

In all the shiftings of population, migrations and invasions an inevitable change in color tone of man will take place, in fact, has been going on and will increase. A certain unavoidable amount of miscegenation will and must go on, which will result in a tendency to greater pigmentation. If one looks at it fearlessly and free from prejudice, he will come to realize that brunette whites will probably dominate the earth, unless of course there should be some sudden, powerful eruption of the blacks, in which case the future earth population will be darker still.

Finally, the resurgence of the Nordics, so staunchly championed by Hitler in Germany and by Madison Grant in our own country, can not in the long run be permanent, as biological, and not political factors, fecundity and ability to underlive other peoples will in the last analysis decide the issue. Perhaps "the meek will inherit the earth" after all.

#### CONCLUSIONS

(1) This problem of population is one for geographers, primarily.

(2) The population saturation point is now placed too low.

(3) The logistic curve for *Drosophila* and other organisms does not necessarily fit human beings.

(4) Birth control and birth selection are imperative if a high plane of civilization is to be maintained.

(5) The Tropics is now the great goal of the whites.

(6) Brunette whites will probably dominate the earth in time.

<sup>8</sup> H. F. Osborn, *Science*, August 26, 1932, "Birth Selection versus Birth Control."

# TECHNOLOGICAL UNEMPLOYMENT

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UNEMPLOYMENT is the most difficult social question of our time. Naturally, the remedy for the situation will depend upon our diagnosis of the cause. It is frequently alleged at the present time that one important contributory cause is the displacement of man by machinery — technological unemployment. Since the accusation calls in question the social benefits of the great technological advances due to scientific research, it has aroused a certain amount of alarm in the scientific world.

Quite recently certain distinguished physicists have rushed to the defense of science in articles purporting to prove that the blame for unemployment can not be laid at the door of technology. Good statements of their views are given in papers by Dr. Karl T. Compton, Dr. Robert A. Millikan and Dr. W. D. Coolidge in the *SCIENTIFIC MONTHLY* for April, 1934. In general, their arguments may be reduced to four. I propose briefly to state each of these in turn and then to comment upon them at some length. I think I can show that some of these arguments, when carefully examined, are not altogether convincing.

The first argument is that science is a great benefactor of mankind, to which we owe our advances in civilization, our increased control over nature and our modern high standard of living. To blame science for our troubles is therefore to accuse the thing which is helping us most.

No one will deny that science has conferred enormous benefits upon mankind, but recognition of this fact leaves the problem of technological unemployment entirely untouched. The point is that this progress has been achieved at the cost of great and undeserved hardship

to many individuals. This has been to a certain extent the case ever since the industrial revolution began, but the problem has become accentuated with the great acceleration of technical progress in the last decade. It is a great mistake, however, to think that it is a phenomenon which became apparent only during the depression. Sumner H. Schlichter, in an article in *The New Republic*, February 8, 1928, entitled the "Price of Industrial Progress," said: "We are obtaining more and better industrial equipment only at the price of heavy investment in unemployment and human misery. We are not getting a bargain. We are purchasing progress at a high price, and the cost falls largely upon those least able to bear it." Is it not fair to ask that society should come to the rescue of these unfortunates? We may scrap obsolescent machinery without scruple if we see any economy to be gained thereby, but to cast aside human beings who have been productive workers is another matter.

There are three parties interested in every technological change: (1) the employer, (2) the consuming public, (3) the workers whose jobs will be affected. As things stand, the question of whether the change shall be made or not is decided exclusively by the employer, who need consider only whether it will result in profits for himself and those he represents. The consumer may perhaps benefit if the business man passes on to him any of the resultant saving, but for the displaced workers it is a calamity equivalent to bankruptcy. In the United States until recently, their fate was regarded as being nobody's business but their own; however, the sheer magnitude of the problem has now compelled this

country to join other leading industrial nations in assuming responsibility for the unemployed.

The second and, if proven, the strongest argument brought against the idea of technological unemployment may be succinctly stated as follows: Science creates new jobs by creating new industries. More new jobs are created than old ones destroyed. For example, the automobile industry employs many more persons than the old carriage and harness industry which it largely supplanted.

This argument to a large degree questions the existence of unemployment caused by technological advance. At all events it regards it as temporary and unusual and as tending to be corrected by the very progress of technology itself.

If certain necessary qualifications are made, we may admit that this contention had a large element of truth down until the last decade. No one will deny, for instance, that the automobile industry, with its many subsidiaries, has given employment to millions of men, nor can it be gainsaid that this industry, and many others less gigantic, are founded on modern science and invention. However, we can not properly infer from statistics showing, for example, that the number of persons employed in the automobile industry is far greater than the number ever employed in the carriage and harness industry, that no problem of technological unemployment was created when one industry largely displaced the other. Statistics deal with men in the mass; they tell us nothing as to the fate of individuals. Yet common sense will tell us that persons for whom a new invention provides work are often not the same persons that it displaces from other jobs. Many people have installed electric refrigerators; the manufacture, sale and servicing of these has created jobs for electricians and others, but these are not the same people as were con-

cerned in the manufacture, storage and delivery of ice.

Some economists meet this problem by the statement that ultimately, "in the long run," the displaced workers will be taken on at other jobs. What we must not overlook is that the worker is vitally interested in the short run. Any prolonged period of unemployment will soon wipe out whatever savings he may have made from his slender earnings as a provision against sickness or old age. Furthermore, in the case of a skilled worker he loses the considerable investment represented by the acquisition of his particular skill. It affords cold comfort to the victim of technological advance to be told that in due time, if in the meantime he can restrain himself for a new kind of work, he may again be employed or that his son will find a job if he can not. Labor is not a fluid form of energy like electricity, which can just as easily do one form of work as another. The idea that the laborer can "find another job" often assumes a knowledge of industrial conditions, a mobility and an adaptability on his part which he does not possess.

The above considerations show that technological unemployment is not new. However, it exists in a much more acute form to-day than ever before. It is not safe to ascribe this condition merely to the depression; indeed, the converse may be true, that the depression is in some measure due to it. The fact is that technological unemployment was becoming marked while we were still (officially) enjoying unprecedented prosperity. Figures released by the Bureau of Labor Statistics in 1928 showed that during the previous five years factory employment in the United States dropped 15 per cent., although population grew by 5 per cent. over the same period. An article published in the *Literary Digest*, March 24, 1928, entitled "Machines Driving Men out of Work," was accompanied by two charts, one showing that industry was

producing more with fewer hands, the other that farm employment was less with more output. Evans Clark, writing in the *New York Times*, pointed out that the crisis in employment was unprecedented in character, because it accompanied prosperity, not hard times.

This tendency toward increasing output with decreasing employment has continued in many lines during the years of depression. For example, in the electric lamp industry, according to the *Monthly Labor Review* of June, 1933, the production of lamps rose from 362 millions in 1920 to 503 millions in 1931, while the number of man-hours worked decreased from over 36 millions in 1920 to less than 11½ millions in 1931. Expressed in index numbers, this means that the index of production rose from 100 to 139, while the employment index declined from 100 to 31.7. In the period 1916-1919 the average production of 25-watt bulbs per man-hour was 52.5; in 1931-1932 it was 4,538.9. Thus the index of output per man-hour increased more than 86-fold in little over a decade, and a still more efficient machine, the ribbon-bulb machine, has been subsequently installed.

The technological progress in the electric lamp industry has been paralleled in so many other industries that a serious situation has been created. We have to face the fact that we can produce more and more with fewer hands, and meanwhile the population is continually growing. Even when industry reaches whatever hypothetical normal may be denominated as "recovery," it may still fall many millions short of absorbing our unemployed. Nor can we solve the problem by any "back to the land" movement, for on the farms also the output per man has been increasing. Fundamentally, it is a problem of distribution, a problem of what to do with goods for which there is no profitable sale. It goes against our whole previous training and experience to give away goods and

services to idle, able-bodied men, yet this solution seems much more sensible than creating an artificial scarcity. There has been too much uncritical acceptance of the assumption that the crisis is due to over-production. As a matter of fact, if the studies of the research specialists of the Brookings Institution, published in "America's Capacity to Produce" and "America's Capacity to Consume," are valid, we still have under-production, and we have not even potentially the ability to produce in excess of the consumptive needs of our population, if everybody is to attain the much-touted American standard of living. Common sense should tell us that the road to prosperity lies in increasing wealth, not in limiting or destroying it. Let us, therefore, expand our production to the maximum, and if even then we can not employ everybody, we shall be able with the surplus more easily to maintain the unemployed. We need not maintain them in utter idleness; we can set them to a wise use of leisure, such as going to school, and pay them for it. If then they should be regarded as favored individuals, we can rotate the work around, giving people alternate periods of work and profitable vacations.

The third argument in defense of technology is that the jobs which science destroys are the drudging jobs which call for hard muscular labor. Thus science lightens man's toil, but the interesting tasks, which call for the exercise of human judgment, are preserved.

That machinery has lightened human toil is incontrovertible. Nevertheless, the tasks it takes over are not always unpleasant and hard; some of the interesting and skilled jobs are included. Moreover, the work of tending a machine is sometimes very monotonous and so simple that it does not develop the worker either physically or mentally.

Finally, I come to the fourth argument, which is to the effect that the dam-



age done by technological advances is not the fault of scientists, but must be charged against the economists and statesmen, who are inadequate to the task of utilizing the benefits of science, while at the same time repressing its potentialities for evil. Sometimes it is added that the responsibility for this failure rests on social science, which has not kept pace with natural science, and our economic crises are the penalty we are paying for this lag. In other words, by this argument the physical scientist escapes all responsibility for the social results of his research. He says, in effect: I increase the powers of puny man a hundred thousandfold; the use to which you put these powers is none of my business. If unwise use of them creates grave problems, I refer you to the social scientist; perhaps he may have some solution to offer.

There is great misunderstanding as to the nature of social science and as to the sphere of its practical application. In the first place, the social scientist does not have his conclusions accepted without question. The natural scientist can ignore the ignorant and the prejudiced, but the social scientist must attempt the often impossible task of convincing them that certain existing arrangements should be altered or that certain experiments are worth trying. Most people have rather decided views about economic, political and social questions, frequently most stubbornly held by those who are least informed. We have only to recall how the pronouncements of economists have been ignored in framing tariffs and in reference to the reparations and international debt questions to realize that the warnings of social scientists often fall upon deaf ears.

Another difference between natural and social science is that social experiments can not be undertaken merely for the sake of the advancement of knowledge, because a social experiment once

launched alters the whole course of history. Any talk about accelerating the progress of social science until it overtakes natural science is pure nonsense. The two are not on the same footing and do not operate in the same realm.

The problem of unemployment very well illustrates the difference. It can never be solved by any technique remotely resembling that employed in laboratory sciences. Any solution which may be proposed is sure to affect adversely some one's interests and so to incur the opposition of human will. An engineer is prone to assume that managing human beings is like managing things; it is simply a matter of inventing the correct set-up. However, in assembling materials he is dealing with objects of known and dependable properties; he never has to contend with any such trueulent and incalculable factor as the human will. The fact that we must recognize—which is not sufficiently recognized—is that social engineering (if there is such a thing) can promise us no certain result, that it will necessarily advance haltingly and with many retrogressions, and that since its progress will involve the readjustment of human relationships, it will always be attended by a certain amount of turmoil.

Whether or not the physical scientist disclaims responsibility for the use which is made of his discoveries, he can not escape the consequences as a member of society. The profound alterations made as a result of technological advances are the concern of all of us. It is a matter of vital importance to us all that science should be a blessing, not a curse. A prerequisite to this end is that we shall approach social problems with an open mind, that we shall recognize that a new situation has been created, that we shall discard ancient shibboleths, and be prepared to cooperate, even at some personal sacrifice, in a sincere effort to distribute the social dividend more fairly than it has been in the past.

# PECTIN IN NATURE AND INDUSTRY<sup>1</sup>

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AMONG the substances found in plant life and of which little is generally known is a group called pectic substances. These substances are found in the cell wall of plant tissue and are grouped into three general classes termed protopectin, pectin and pectic acid.

Protopectin is the water insoluble, unhydrolyzed pectic substance. This substance is changed to the soluble pectin by treatment with enzymes, acids or other reagents in a variety of ways. Pectin is the water soluble intermediate substance or group of substances found in ripening or ripe fruits. This material is changed by enzyme or chemical hydrolysis and complete elimination of methyl ester groups to the final pectic substance—pectic acid—associated with the breakdown of tissue and decomposition.

The chemistry of these pectic substances has been studied extensively. It is generally agreed that a polymerized galacturonic acid anhydride is the basic unit of pectin and that in addition the compound contains arabinose, galactose, acetyl and methoxyl groups. The size of the nucleus and the amount of other constituents have not been agreed upon, but they evidently depend on the method of extraction and will vary. The latest results give the unhydrolyzed pectin an octagalacturonic acid nucleus.

Braconnot, a French worker, is credited as being the first to extract pectous material from plants. This work was published in 1825, a little over one hundred years ago. He extracted what he termed pectic acid from the roots of

several vegetables and from the leaves and stems of plants and trees. Braconnot took the name pectin from the Greek word *πηκτω* meaning coagulum. As research was conducted down through the past century it became firmly established that pectin was the primary constituent of the middle lamella of the cell wall of plant tissue.

Studies have been carried out on the constitution and extraction of pectin from fruits, vegetables, leaves, buds, twigs, seed kernels, straw, roots, stalks and even from cork. All these sources have pectin in various amounts, some evidently with a slight variation in constitution, but nevertheless a pectous substance. The two largest sources of pectin utilized at present are the albedo of citrus fruits and the pomace of apples.

Pectin is important in every phase of the growing plant. It is found in the root hairs of seedlings. These small hairs have a layer of pectic material on their outside. C. G. Howe in the *Botanical Gazette* for 1921 suggests that the fact that virgin soils yield full crops may be due to the structure of the root hair which enables it to change the difficultly soluble constituents of the soil into food for plant growth. It may be that the medium for this exchange of plant food is the colloid pectin.

Plants normally have pectic substances distributed throughout their growing parts. A change in normal pectic content is generally associated with some disturbance. Disease such as "silver leaf" afflicting apple leaves has been found to be accompanied by a decrease in normal pectic content. After injury to plant tissue by insect attack or bruise, the wound tissue which forms

<sup>1</sup> Published with the consent of the director of the Delaware Agricultural Experiment Station.



contains a greater amount of peptic substances than ordinary plant tissue. E. J. Candlin and S. B. Schryver, English workers, found that as the plant tissues become lignified the pectin gradually disappears, evidently due to decarboxylation to lignin and hemicellulose. However, throughout the succulent, growing tissues of the plant peptic substances are found.

The ability of plants to resist cold and their susceptibility to hardening is dependent upon the water held by colloidal adsorption, according to J. T. Rosa in University of Missouri Research Bulletin No. 48. With an increase in hydrophilic colloid content in the protoplasm of plant cells there is an increase in imbibition. Changes in the acidity of the plant tissue are also responsible for changes in the water-retaining power of the colloids present.

In the fruit itself, pectin seems to have an important part in the growth and ripening. We happen to be the most interested in the peptic substances of this product of the plant because it is from the small, inferior or surplus fruit we wish to extract pectin for commercial use.

In the case of the apple, in the early stages of ripening no soluble pectin is found. As ripening proceeds the pectin gradually changes to the soluble state. The presence of soluble pectin reaches a maximum which coincides with ripeness of fruit and then, as the fruit changes from the ripe to the over-ripe condition, the pectin content decreases with a corresponding increase in its decomposition products.

Since we are dealing primarily with the uses of pectin we will only stop momentarily to mention that the extraction and recovery of pectin from the fruit or plant source is carried out with the idea of converting the proto-pectin to the soluble pectin without an accompanying decomposition of the pectin.

Heat and acid are usually applied to extract the material. Other methods specify extraction by electrodialysis, by osmosis or by enzyme action. The extract finds its way to market in a concentrated product as a liquid, a dry powder or a film. The extraction, recovery and preparation of pectin for the market is a complex subject. Many patents have been taken out specifying various methods of processing.

Since pectin is most familiar as a jellying agent let us consider its use in jelly and jam manufacture. It is used for making up the synthetic pectin-sugar-acid jelly of special flavor and color, such as mint jelly. It is required to jelly bottled juices where the original pectin has been destroyed, either intentionally or not, in the preparation or storage of the juice. With some fruits where the pectin is naturally low or where the extraction treatment has been too severe more pectin must be added for jellying purposes. The jellying properties of any fruit juice depend upon the quality and quantity of its pectin content and its pH (active acidity). The pectin characteristics can be determined by measuring the viscosity of the solution. The optimum acidity is very hard to determine, and actual trial of the quantity of acid needed is the only satisfactory method. By measuring the viscosity of a fruit juice extraction an indication of the sugar-holding capacity is obtained, provided the acidity is adjusted to the optimum, which will be found in the neighborhood of a pH of 3.

There are certain advantages in using pectin in the preparation of jams and jellies. The amount which need be added is relatively small—if a purely synthetic product is made from a 100-grade pectin only 0.65 per cent. pectin need be used at the most. In cases where the fruit is only slightly deficient in pectin, very small quantities need be

added. When pectin is added jam or jelly can be made with any available fruit. It is also possible to cut down on the cooking time if the pectin quality is good, because a larger pectin content will support more sugar and less water has to be evaporated. Thus a lighter-colored and generally more attractive product is obtained. Since more sugar may be added the yield of jelly is increased and the cost of the product reduced. Of course this must not be done with any sacrifice of flavor. The viscosity method is really the only reliable way to tell whether more pectin should be added to fruit-juice extractions, because by this method you have definite figures of the sugar required and the final weight of jelly to be produced.

Many patents are issued on the manufacture and preparation of pectin to be used as a jelly base. The liquid pectin is quite familiar to the public. The dried pectin is becoming better known. Combinations of sugar, acid, salts and pectin are mixed up with the hope of easy solubility. Pectin alone has a tendency to clump, or ball up, when put into solution. By adding a carbonate or bicarbonate and an excess of acid to the pectin base when the product is put into water effervescence occurs and the pectin particles are held apart so that they disperse more readily. Particle size influences dispersion also. The acidity of these preparations is regulated so as to compensate for the lack of sufficient acid in certain fruits.

The use of pectin in the manufacture of cranberry jelly seems rather unnecessary since cranberry has such an abundance of this material. However, a late method specifies the destruction of the natural pectin by a pectinase, a pectin-decomposing enzyme and the addition of commercial pectin to replace it. The value of this procedure lies in the fact that the amount of pectin added can be controlled. There is apparently much

more research which could profitably be undertaken on the subject of cranberry jelly.

In close association with the use of pectin in jam and jelly manufacture is its use as a thickening agent for soda-fountain syrups and crushed fruits. Pectin on account of its jellying characteristics makes a thick, heavy syrup which tends to stay on top of the ice cream and gives an impression of richness to the consumer. More body is imparted to the sodas which are made up with these viscous syrups.

While we are considering sweets, we must mention a new "gum drop" with pectin jelly center which is having good sales. These candies can be made up with ease and keep fresh without turning sticky or hard. When made right they are tender and firm, and when bitten into are of a brilliant sparkling color. They make a very attractive showcase display. Pectin also produces a firmer apple concentrate candy, the famous Virginia product.

Tomato juice for cocktails and catsup are benefited by added pectin in that it makes them more viscous, which improves their physical appearance. Pectin also increases the resistance of the product to separating into layers of pulp and liquid.

Pectin has been added to fruit juice intended for beverage purposes previous to spray drying. In such an instance pectin acts as a carrier which helps to hold fruit essences and gives the syrupy characteristics demanded by the beverage consumers. It also prevents agglomeration of the solids present. Other beverage bases utilizing pectin are combinations of milk, pectin and fruit juices dried together.

It is said that pectin improves the texture, yield and moisture-holding capacity of baked food products. The staling process in these foods is definitely slowed up. This use may easily be abused by

trying to introduce too much moisture, so much so that the total solids content is lowered abnormally and aging is accelerated. In connection with the baking industry, pectin improves the texture and time of set of meringues and frostings.

In dairy products, such as milk, pectin acts as a protective colloid and has a definite stabilizing action. Similar to gelatin it improves the texture of ice cream. The incorporation of a small amount of a stabilizing colloid such as pectin in cream cheeses and those of the "club" type allows the heating of the cheese to kill organisms naturally causing rapid deterioration. The colloidal matter preserves the normal body and texture of the cheese through this heat treatment.

The use of pectin in foods is considered beneficial to the digestive system; similar to malt it acts as a protective colloid. In Germany, Dr. Kurt Imhauser introduced 30 to 50 gram portions of dry citrus pectin in water to the stomach of several dogs. He found that the blood sugar did not go up definitely but showed only slight variations with no definite trend. He also found that pectin given to phloridzinized dogs did not protect the liver from fatty degeneration, which means that there are no utilizable carbohydrates derived from pectin. The administration of 30 grams of pectin to a dog reduces the amount of acetone bodies in the urine—showing an antiketogenic effect, galacturonic acid being a possible source of this action. Thus pectin may be considered safe even for inclusion in a diabetic's diet.

Pectin is an excellent constituent of pharmaceutical preparations on account of its high viscosity and colloidal properties. It is especially valuable as an emulsifying agent in such preparations as emulsified castor oil. It is used in hand lotions and hair dressings. However, its usage in the pharmaceutical field has been kept more or less secret.

Rooker suggests the use of pectin as a glue or mucilage on account of its adhesive characteristics. This can only be accomplished by the use of preservatives. That it is too expensive to compete with materials of this type is acknowledged. The price of pectin is admittedly high, but with an increase in the uses to which it may be put, new methods for producing this product will be developed. A larger demand will allow larger units of production, all of which will tend to lower costs.

In connection with the textile industry ways and means of getting rid of the pectin are usually sought. The retting of flax and subsequent fermentation is a process involving the destruction of the pectic material present so that the tissues may be more easily macerated and the fibers separated. A combination of anaerobic and aerobic organisms or various fungi which secrete pectic decomposing enzymes are used for this purpose. Four to eight per cent. of pectic material has been reported present in flax stalks. If this pectin is not removed, cloth made from the fiber will be discolored after long storage or by washing in alkali. The tensile strength will also be impaired.

Comparative tests of the use of pectin (from beets) and of starch for finishing textiles reported by Lyubimov (from abstract in *Chimie et industrie*) have shown that: There is practically no difference as regards the strength of the warp. The pectin treated fibers can be worked as well on Platt looms as on Northrup looms. The pectin treatment is much the simpler. Satisfactory results are obtained with pectin, even without the addition of auxiliary substances such as glycerol, soap or tallow, generally used in conjunction with starch. The use of 7 per cent. pectin is sufficient to dispense entirely with starch and is much cheaper.

Russian and Japanese investigators have associated pectin and tobacco qual-

ity. In cigarettes, the pectic content varies between 9 and 20 per cent. and, in cigars, between 13 and 15 per cent. The poorer the quality of tobacco, the higher is its pectic content. This pectin, present as calcium and magnesium pectate, is claimed to be similar to flax pectin. The fermentation process is stated as having no effect on the pectin content. Probably the pectin goes to pectic acid because there is a loss of methoxyl reported during the period of curing and fermentation. Pectin is the chief source of this methoxyl. The loss of methoxyl during fermentation is reported as small in high-grade tobaccos. In the tobacco plant the content of pectic material and methoxyl is higher in the upper leaves, reaching a maximum in the top leaves.

In the sugar industry, small amounts of pectin are extracted due to the presence of pectin in both the beet and sugar cane. In the fresh beet pulp there is about one per cent. pectin, and there is about the same amount in cane fiber. Assuming that the pectin is left in the juice it would amount to about 0.15 per cent. in the molasses when a process of extraction of the sugar by diffusion is used. Ehrlich claims that during liming of the juice polygalacturonic acid is formed which is precipitated as the calcium salt. Farnell says that experiments show that neither by acid nor alkali clarification nor by hot or cold liming are any appreciable amounts of the pentosan removed.

According to Semichon and Flanzy, pectins present a means of distinguishing natural liquor wines obtained by over-ripening and sun-drying of grapes from liquor wines obtained by artificial concentration of the must. The pectins in natural wines are much higher. The pectin content varies with different wines. Grapes which sun-dry readily give musts rich in pectin and mellow wines. Those which do not dry readily give musts low in pectin and dry wines,

lacking mellowness. Dry wines can be mellowed by heating fresh grape skins with part of the must. This converts the protopectin of the skins into soluble pectin. The mellowness is credited to be favored by the dissociation of the methyl pectic ester and the combination of the methoxyl with the essential oils and oleosins contained in the grapes.

In unfermented juices, such as grape juice and apple cider, it has been found that clarification produces a clear, brilliant juice. Pectin, as a colloid, aids in the suspension of other material which clouds the juice. Several ways of decomposing pectin are employed which aid in clarifying the juice. Flash heating (the application of heat to raise the juice to 180° F. for 20 seconds), use of another colloid, such as casein or gelatin, and use of enzymes secreting pectase have been tried to accomplish this purpose. The pectin is converted into soluble substance or flocculated and filtered off. By adding pectin to juices, just the reverse of the above process is accomplished. Juices so treated may be made to appear as though freshly extracted.

Small amounts of pectin in solution aid in crystal growth, according to Ehrlich. Long pointed crystals of ammonium chloride, weighing several hundred grams and a meter long, were obtained. Similar enlargement of crystals of ammonium bromide, ammonium sulfate, potassium chloride, potassium nitrate, barium chloride and boric acid were obtained.

In the use of pectin as an emulsifying agent for tree sprays, we find pectin being applied to the fruit from which it is eventually obtained. This use is negligible at present, owing to the high price of the commercial pectin. The application of preservative surface coatings of oils and waxes on fruits incorporating pectin as an emulsifying agent has been suggested.



Patents covering the use of pectin in the so-called "creaming" of rubber latex have been issued. Certain hydrophilic colloids when added to rubber latex cause the latex to separate into two layers similar to the separation of cream from milk in the dairy industry. The portion corresponding to skim milk contains water and serum made up of proteins, sugars and other impurities. The portion corresponding to the cream is higher in rubber particles by an amount in proportion to the degree of creaming. This creaming is caused by the colloid surrounding the rubber particle and causing a slight change in the specific gravity of the particle. With the equilibrium upset, the rubber particles tend to form an upper layer. After drawing off the serum the "creamed" layer is subjected to a hydrolyzing action which decomposes the pectin. A saving on shipping costs is readily seen by this process as well as a product containing a lower percentage of non-rubber constituents.

A new use for pectin which holds out possibilities of large consumption is the hardening of steel by pectin solutions. It is claimed by Ripa that the heat conductivity of pectin solutions is approximately the same as that of oils ordinarily used for the quench hardening of steel. Varying degrees of hardness may be imparted to the steel by varying the concentration of pectin, which, of course, can be easily adjusted to any concentration in water solution. Concentrations of 0.5 to 15 per cent. pectin (dry) in solution are specified as having been used. A low concentration of pectin produces a very brittle and hard steel. Tool steel, a hard, tough product, requires about a 4 per cent. solution. Among the advantages of pectin solutions over oils for this purpose are: easy regulation of heat conductivity, non-combustibility, one operation for the hardening and tempering, and favorable competition on a price basis.

Naturally, it is only with large-scale usage and a cheaper cost of production that other uses will be presented. A recently suggested use for pectous substances is as a condensation product. Such a use would call for quantity production. The sources of the pectin substances for this use are from such materials as cereal straw, flax, hemp and corn stalks. The pectic liquor, extracted by heating these substances with water or steam, is filtered off and evaporated to a heavy, viscous, dark-brown residue, similar to heavy molasses. By reacting this pectous residue in the presence of formaldehyde and a condensing agent under such conditions as to initiate an exothermic reaction under regulated conditions an intermediate condensation product is obtained. This intermediate product, a thinly viscous material, is soluble in water or other volatile solvents. Allowed to stand exposed to the atmosphere it will become insoluble but still retains its properties of fusibility. This intermediate condensation product may be used as a saturant for fibers or fabrics, and with application of pressure and heat, in the production of a hard-board product.

By reacting the pectous residue in the presence of an aldehyde and a ketone, using an alkali as a condensing agent, a resin is produced having many of the characteristics of the phenol formaldehyde resins.

A plastic composition adapted to serve as an impregnating material in the lamination of sheets of fibrous material is also obtained from the pectous residue. This type of plastic is obtained by adding an excess of a ketone as a retarding agent to prevent the intermediate stage of condensation from progressing. Upon adding a hardening agent such as hexamethylene tetramin and heating the mass infusibility and insolubility are induced. This composition may be used as a binder for abrasive substances, composition wood and the like. In the final

stage it is claimed that it is infusible and insoluble in such solvents as acetone, amyl acetate or ethyl alcohol, and very resistant to the action of acids or alkalis.

These various uses for pectin are naturally only worthy of development if they can compete with established products on a price basis. We have in pectin a product of definite colloidal properties of high viscosity and high emulsifying power. With further knowledge of the properties of pectin and pectic materials it can well be assumed that other uses

will be found. It is hoped that enumeration of present uses will create more interest and suggest new uses for pectin that it may be a greater source of profit to the orchardist and manufacturer of the future. At present, only a small portion of the waste fruit out of a total annual production of over 150,000,000 bushels of apples reaches the cider press. In turn, only a fraction of the pomace which is dumped from the cider mill finds its way into a more complete recovery of by-products in the extraction of pectin.

## LOCATING PROPERTY BOUNDARIES

By Professor S. S. STEINBERG

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It is generally admitted that the widespread ownership of land is one of the important factors making for the stability and well-being of the nation. It is likewise generally known that boundary disputes between nations have frequently led to wars, and such disputes between private owners of property have led to ill-feeling, confusion, litigation and loss of money. Therefore, anything which contributes to the security of land tenure, reduces its costs and makes for cordial relations between neighbors, whether they be nations, states or individuals, merits careful and sympathetic consideration. Land being one of the most important things that the human race owns, it is essential that the custodian of a piece of property, whether public or private, should know where the boundary lines are.

Land surveying, the art of measuring land and of delineating its boundaries on a map, is generally supposed to have had its rise among the ancient Egyptians, due to the river Nile's destroying and confounding all their landmarks by its annual inundations. This put the

Egyptians to the necessity of inventing methods and measures to enable them to distinguish and adjust the limits of their respective grounds when the waters were withdrawn. The Egyptians, in addition to being the first to measure the earth, likewise were the first to determine the relations between the heavenly bodies. Their knowledge of these matters was engraven on columns and by that means delivered to posterity. It is interesting to note that the modern engineer or surveyor makes astronomic observations for use in all important mapping as did his predecessor in early Egypt.

The present system of locating property boundaries is based on the belief that a point on the earth's surface can be perpetuated by placing on it some physical object for a marker. Many centuries ago the Egyptians learned the fallacy of that theory, but we still adhere to it. In a recent city improvement, a boundary monument of massive concrete was lifted out of the ground by a steam shovel even before the engineer could reach a tape to it to locate its



former position. If a monument like this is impermanent, what hope is there of an enduring future for the stake, the pile of rocks or the blaze on a tree, which commonly mark farm boundaries?

It might be of interest to cite from an old deed the description of the starting point of a tract of land which read, "Beginning at a point on Powder Mill Run where Bill Jones killed the Indian." Needless to say, that corner could not be found. Also, there are many cases where excellent surveys have been of only temporary value because the surveyors making them left no permanent monuments.

There is nothing that causes more trouble to an owner of a piece of property than to have doubt raised as to the exact location of his land. He may wish to sell the land and give clear title to it, or he may wish to raise money on it. In either case he must be certain that the exact locations of his boundaries are known. His boundaries will be known if he has placed substantial monuments at their turns, setting the monuments in such a way that they are not likely to be disturbed by man or nature. A small amount of concrete, properly placed, will make an excellent mark, and to establish such a landmark will cost an insignificant amount compared with the cost of doing the survey work over again.

Landmarks have been the subject of legal action for thousands of years. Back in the time of Moses, in 1500 B.C., the laws protected survey monuments. One of these laws read: "Cursed be he that removeth his neighbors' landmarks, and all the people shall say Amen." Job, in speaking of the wrong-doing of his people, listed the removal of landmarks as one of the reprehensible acts they committed. Solomon, in his Proverbs, said, "Remove not the ancient landmarks which thy fathers have set."

In the United States, during Colonial

times, with land plentiful and population very scarce, only the crudest kinds of surveys were made on the outlines of a grant from the King or the Colonial governor. After the Revolution, with the western area of the country opening up for settlement, a method of laying out the public lands in squares approximately one mile on a side was adopted. The land there was plentiful and it was not feasible to use exact surveying methods in establishing these township range and section lines. To have done this work in an exact way would have made the cost excessive as compared with the value of the land.

The early surveys were notoriously inaccurate. Practically all the surveying was done with the compass and the chain. Measurements of angles and of distance were made by methods that were crude and unreliable, and frequently no account was taken of the magnetic attraction of the earth on the compass needle. Finally, it was the common practise not to close the circuit of the property boundaries. There are many deeds on record in which a description encircles the greater part of a tract and, having run to a spot somewhere in the vicinity of the starting point, closes with the charitable phrase, "and thence to the place of beginning."

Because of these inaccuracies, it has come to be the well-established court practise that the actual positions of the boundary marks on the ground, if they can be established with reasonable certainty, will control rather than the metes and bounds as given by the surveyor.

Conditions, however, have changed with the years, and land that was originally worth a few cents or a few dollars an acre may now be worth a hundred or even a thousand dollars an acre. In some of the large cities, lots are worth thousands of dollars a square foot. This increase in the value of land necessarily calls for an increase in the accuracy

with which the boundaries of the land are surveyed. The engineer's transit and the steel tape have replaced the compass and the chain.

In addition to the thousands upon thousands of conflicting private property boundaries, there are scores of state boundaries in the United States which have been subject to controversies in the past or may at some future time require redetermination. It is a general legal principle that when a boundary is once accepted by the custodians of abutting properties, it is the boundary for all time to come. But the question arises: "How can a boundary be so located that it might be easily recovered in the future?"

An answer to this question is furnished by the Geodetic Control Surveys that were conducted in Maryland during the past winter under the auspices of the United States Coast and Geodetic Survey and in cooperation with the College of Engineering of the University of Maryland. Similar projects were undertaken in the other states. They were financed by the Civil Works Administration as a means of employment for engineers and for the performance of a work of great economic value to the people of the states. Some 420 Maryland engineers, surveyors and assistants, operating in all sections of the state, were engaged in establishing control lines and elevations which provide a basis for accurately tying in land surveys in the future. In addition, these points serve as fundamental control for all engineering projects that might be undertaken in any community.

In conducting the control surveys the general practise is to follow the improved highways, since the aim is to establish points in places readily accessible. The monuments used are three-foot concrete posts which are set flush with the ground at the edge of the road right-of-way. The monuments set west

of Frederick were four feet in length, due to lower frost line. The top of the monument has a bronze cap on which will eventually be stamped the number of the marker and its elevation above mean sea level. Monuments are set in pairs one quarter of a mile from each other, with each pair about two miles apart. They are established in every town on the circuit and at important crossroads, so that engineers will have these reliable points for referencing any survey or engineering project in that vicinity.

In establishing these monuments extreme accuracy of measurement is required. Distances are determined with a steel tape which has previously been compared with a master tape standardized by the National Bureau of Standards. The tape is stretched carefully between special chaining tripods, and in stretching it a spring balance is used at one end to make certain that the required tension is given. At the time of each tape measurement a thermometer reading is taken so that correction may later be made for increase or decrease in length of the tape due to temperature. All distances and elevations are determined to the nearest thousandth of a foot.

These control surveys have a real value to every owner of land, whether of a farm or a city lot, because a land survey which has been tied into such geodetic control is indestructible. Should every point of such a survey be lost or destroyed, the property boundaries can be retraced and the old points relocated. This is possible because the geodetic control is part of the triangulation network which has been established throughout the country by the United States Coast and Geodetic Survey in the past hundred years of its operation. Any survey so referenced becomes tied into the geography of the United States, and as there is only one point on the earth's surface

that has a given latitude and longitude, that point can be recovered at any time in the future.

To facilitate surveying of counties and other local areas, computations have begun, as part of the Civil Works Administration project, on a system of referencing points in Maryland which will eventually permit coordination of land or engineering surveys in the state. At present at least three separate and unrelated groups of surveys are in use in Maryland; namely, those in Baltimore, in Annapolis and in suburban Washington. When the single coordinated system for Maryland is fully computed it will be a comparatively simple matter to have these three different units referred to the state-wide system and thereby facilitate surveying operations between those three cities and, also, its extension to the remainder of the state.

It would be advantageous for each state to have a land court, in which all disputes over property boundaries could have a hearing. Since laws relating to the ownership of property are very complicated, it is reasonable to expect that such a court, concentrating on boundary matters, could render decisions more expeditiously than one not so expert. Massachusetts has had a land court for some years. There the law requires that private property boundaries be connected with the control system of the state. The township lines were definitely located and tied into the Coast and Geodetic Survey network and monuments were set upon these lines, thereby making them available in that state to any engineer or surveyor who undertakes a boundary survey.

One of the newest developments in land surveying is the use of the airplane for taking aerial photographs. With geodetic control monuments on the ground serving as a "yard-stick," maps can be constructed with little difficulty from the assembled photographs. This method, which speeds the work and reduces the cost, has been found very useful in locating boundaries of large tracts of land, in city planning and in mapping inaccessible areas. The land areas in Baltimore and in the vicinity of Annapolis have been surveyed from the air, and the resulting maps have been found extremely valuable in defining property boundaries and for many engineering purposes. By means of aerial photography in certain states, parcels of land have been discovered that were not previously listed on the books of the tax assessors.

All Europe, Mexico and many countries of South America have accepted geodetic control, and in those countries it serves as a foundation for all surveying, whether public or private.

As a result of the impetus given to this work last winter under the Civil Works Administration, it is hoped that sufficient funds will be forthcoming for the extension of this project in all the states to a point where geodetic control would become generally available for use by engineers and surveyors in their work, and particularly in so locating boundaries as to avoid overlapping of adjacent properties. Boundaries that are connected with geodetic control are really tied to the stars; and, as the motions of the heavenly bodies are immutable, so, by the use of this system, will property boundaries become definitely established for all time.

# POLLEN GRAINS AND WORLDS OF DIFFERENT SIZES

By Dr. R. P. WODEHOUSE

YONKERS, N. Y.

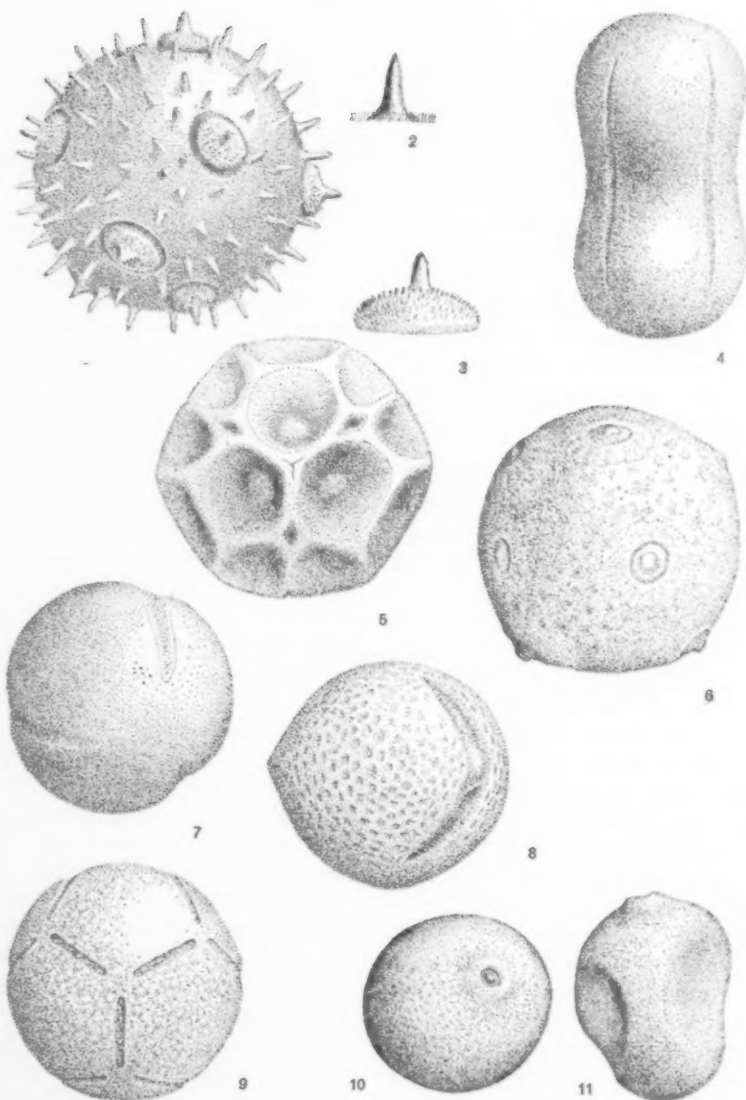
PERHAPS the first question that one is going to ask himself upon approaching the subject of pollen morphology is: Why are the forms of pollen grains so odd and strange—so different from the things that we are accustomed to seeing in everyday life? It is true they are not all alike; unrelated species can easily be told apart, and often the differences between them are very great. Nevertheless, great as these differences are, they are trifling as compared with those that exist between pollen grains and the things that we are accustomed to seeing without a microscope. The microscope shows us another world. And truly this is the answer to our question. Pollen grains belong to a world of another size.

## THE WORLD OF GRAVITY WALKERS

There is a law of nature which places a handicap on bigness; the larger an animal is the greater the difficulty it has to move. Mathematicians have a more exact way of stating this law. They say the surface or cross-sectional area of a thing is a function of the square of its linear dimensions, while its volume is a function of the cube of the same dimensions. Among the everyday things that we know, this disproportionate increase of volume or weight over area that is encountered in an object increases in length and breadth, limits the size of animals which, for example, may walk comfortably bearing their weight on their feet, to about the size of an elephant. Animals very much larger, like the whales, must live in an aquatic medium that supports their bulk, for it would be to-

tally unmanageable on land. At the other end of the series, a mouse is perhaps the smallest animal that has weight enough to get traction for its feet, and even it freely uses its claws for that purpose. This is the world of our size, bounded at the top by about the size of an elephant and at the bottom by that of a mouse. It is the world in which we perform most of our activities and to which we are best adapted. We need no lenses to see all of it and we need no mechanical aids to handle things in it, hence our feeling of being at home in it.

In this world of elephants, men and mice, animals walk on four or two feet, and the bearing of their weight, particularly among those near the upper limit, is perhaps their most serious structural problem. All beings, both plants and animals, which inhabit this size world, are primarily shaped by the asymmetrical or one-directional pull of gravity. The plant directs its stalk upwards against the force of gravity and its roots downwards with the force of gravity, while its branches may be symmetrically arranged around the vertical axis; and for the same reason animals differentiate an upper and lower side. But the forces of this size world tend to impose a further limitation of symmetry on all beings in it which move, for in response to a motion which is always at right angles to the gravitational pull, front and back ends are likewise clearly differentiated. Nature's tendency to make all things as symmetrical as possible is thus thwarted in all directions, except laterally, but here it asserts itself. Thus it is that beings which move in this world are



HIGHLY MAGNIFIED POLLEN GRAINS

THAT OF THE FORGET-ME-NOT AT THE SAME MAGNIFICATION AS THAT OF THE SQUASH IS ABOUT AS BIG AS ONE OF THE SPINES OF THE LATTER. (1) SQUASH (*Cucurbita Pepo* L.), 150  $\mu$  IN DIAMETER. (2) A SINGLE SPINE OF THE LATTER MORE HIGHLY MAGNIFIED. (3) ONE OF THE CAPS OF THE LATTER MORE HIGHLY MAGNIFIED. (4) FORGET-ME-NOT (*Myosotis sylvatica* HOFFM.), 6.8  $\mu$  LONG. (5) *Oryctanthus botryostachyus* EICHL., 34.2  $\mu$  IN DIAMETER, A MEMBER OF THE MISTLETOE FAMILY. (6) PLANTAIN (*Plantago lanceolata* L.), 35  $\mu$  IN DIAMETER. (7) ST. JOHN'S WORT (*Hypericum perforatum* L.), 10  $\mu$  IN DIAMETER. (8) COMMON ELDER (*Sambucus canadensis* L.), 18.2  $\mu$  IN DIAMETER. (9) MOUNTAIN COBYDALIS (*Capnoides montanum* BRITT.), 26  $\mu$  IN DIAMETER. (10) TIMOTHY (*Phleum pratense* L.), MOIST AND EXPANDED, 37.5  $\mu$  IN DIAMETER. (11) THE LATTER DRIED AND SHRUNKEN.



characterized by a right and left, or bilateral symmetry. It is the only one possible to them.

Among animals which move in this world flight is seldom undertaken and is hazardous, except towards its lower limit. It may be called the world of gravity walkers. Within it forms of things may be very different; yet, when compared with those of either the world of larger things, which is perhaps the world of planets and solar systems, or with those of the world of next smaller things to which the insects belong, they seem much alike.

#### THE WORLD OF EASY FLIGHT

Within this world of smaller things gravity and movement impose the same type of bilateral symmetry, as before, upon the beings which inhabit it, but its lessened effect brings about some curious results. The support of bodily weight is not a problem; instead, the effect of gravity is too weak to give sufficient traction for convenient walking on four or two feet in the usual way. Feet must be provided with suction disks or with hooks. In this world of lessened gravitational effect it is nearly as easy to walk across a ceiling or up a vertical wall as it is along the floor. In it flight is the rule and not the exception, and it is attended with no hazards. So much is this so that it may be called the world of easy flight. It is a world in which we are not at all adapted and can play no part without special aids. Even for us to observe most of it a good lens is a help, and to handle objects in it forceps and other instruments are necessary. Among its inhabitants insects predominate, for their structure, which is far different from that of elephants, men and mice, is beautifully adapted to movements within its size limits.

Though the effect of gravity is so far reduced that flight is easy, its accomplishment requires muscular effort.

Only the smallest inhabitants of this size world attempt to float without muscular effort, and when they do they must devise some special floating mechanism, such as the tuft of silk of the balloon spider or the crown of pappus of the thistle seed.

#### WORLD OF FLOATING AND STICKING

In the next smaller size world, the one to which spores and pollen grains belong, floating is easily accomplished. No wings are used, because none is needed. It is a world of objects so small that when they are free they float, for the effect of gravity is not strong enough to pull them down against the slightest current of air, and when they touch they stick, for the effect of gravity is not strong enough to pull them loose again. But the lack of gravitational effect has an even more important influence, that is, upon the symmetry of the beings of this world; as a consequence of it, their top and bottom sides are not differentiated. Moreover, they do not have any independent forward motion with its consequent differentiation of front and back ends, and they are therefore rarely bilaterally symmetrical, and when they are, it is for reasons of another category. With organisms of this size world, symmetry, which in nature tends ever to be as complete as possible, has much fuller sway and reaches a much fuller expression. Since the sphere is the most perfectly symmetrical figure, it is not surprising to find that beings of this world are basically spherical; it could, indeed, be called the world of spheres. This is, perhaps, the most outstanding character of pollen grains—they tend to be spherical and their sculpturing is nearly always of a much higher order of symmetry than the bilateral, to which we have become accustomed in our world and in the world of easy flight. Is it any wonder that the forms of pollen grains look odd and strange to us?

The range in size of pollen grains does not exactly coincide with the range of the world of floating and sticking. It extends perhaps a little beyond at the upper end, but falls far short at the lower, for there are spores which are far smaller than pollen grains and still float freely in the air. The largest pollen grains, as, for example, those of the pumpkin which are about 200  $\mu$  in diameter, are so large that they can not float easily, but they can stick, with the help of a little oily adhesive, so they travel by sticking to insects. From this size pollen grains range downwards to about that of the forget-me-not, which is three microns in diameter. But it too travels by sticking to insects. It is an interesting fact that among pollen grains, only those of intermediate sizes are the best floaters. Invariably both the very large and the very small are exclusively stickers. Only those between fifty-eight and seventeen microns, with one notable exception, are good floaters. The reason that those above this range are exclusively stickers is obvious—they are just a little beyond the size range of easy floating, but still within the range of moderately easy sticking. But the reason that those below this size range are also almost exclusively stickers is not so easy to see. It may be that their small size, with its attendant disproportionately large surface area, is a hindrance to them in leaving their anthers or in separating from each other. That this is so seems likely from the exceptional case of the pollen of the paper mulberry. It is air-borne, yet its grains are only thirteen microns in diameter, which is well below the size range of most air-borne pollen. It is, however, forcibly ejected from the anthers in a rather spectacular manner. If a flowering branch of the paper mulberry is kept in water its pollen will be seen to puff out from the flowers, like puffs of smoke, over a long period of time. Also many fungi,

whose spores are even smaller—yet are floaters *par excellence*—are provided with an efficient mechanism for throwing the spores clear of the plant and of each other. The reason that only moderately large pollen grains are floaters is probably to be found in the inability of most plants to develop a satisfactory ejecting mechanism.

#### RESEMBLANCES OF POLLEN GRAINS TO PROTOZOA

Many people have marveled at the resemblances between pollen grains and such minute aquatic organisms as the Radiolarians and Heliozoa. The shells of these animals are generally made of some silicious or calcareous material, chemically entirely unrelated to the exine of pollen grains, yet they appear to bear a quite remarkable resemblance to them. Their basic form is spherical and their sculptured patterns are similar to those of pollen grains in their symmetrical completeness. The question naturally arises: How do these organisms come to resemble pollen grains, since their shells are of an entirely different composition and they live in an aquatic medium? The resemblance that they bear to pollen grains is due solely to the fact that they live in a similar size world. They are floaters and stickers without independent movement in an aquatic medium, just as pollen grains are in an aerial medium. And, freed from the asymmetrical influence of a one-directional gravity, and a one-directional movement, they have become as nearly perfectly symmetrical as pollen grains, assuming the spherical form and somewhat similar sculptured patterns. Looked at more closely, however, it is seen that the resemblance is no more than this. Their sculptured patterns are composed of different elements of symmetry, belonging to different mathematical series. For example, the underlying series among the patterns of pol-

len grains is that of the tetrahedron, cube and pentagonal dodecahedron, always with three equal angles coming together at a point; while the patterns of the most similar protozoa, as for example, *Circoporus* and *Circogonia*, are built on the plan of the octahedron and icosahedron, which require four angles coming together at a point, a condition which is never encountered among pollen grains. Such differences as these are basic and, measured in terms of the world of floating and sticking objects, are far greater than—let us say—the difference between a man and a crocodile, measured in terms of our world of gravity walkers.

The actual similarity that all the inhabitants of the world of floating and sticking bear to each other is due to the fact that within the size limits of such tiny objects as spores, pollen grains and protozoa, much less diversity of form is possible than within the worlds of larger objects. It is true that at its upper end and, in fact, through the greater part of its range which is occupied by pollen grains, considerable diversification of form is possible. The large pumpkin pollen grain, those of the *Malvaceae* with a diameter of about 153 microns, and of the four o'clock, with a diameter of about 180 microns, are elaborate and beautiful objects. Nowhere among the grains of smaller orders of magnitude do we find anything approaching the multiplicity of their detail and beauty of pattern. And as we pass downward in the series of grains arranged according to their size, they become less and less ornate. The smaller pollen grains are practically without decorations, excepting germinal apertures of the simplest kind, or germinal furrows of an equally simple kind, and as we pass over into the domain of spores which are still smaller,

even these are missing. Indeed, the smaller spores in their simplicity and plainness of form are quite like bacteria, which are the inhabitants of the next smaller size world.

In the world of bacteria and organisms of similar size the forms are all so simple that it is difficult to distinguish most of them by their morphological characters. For that reason the bacteriologist must rely mainly upon physiological characters for purposes of classification and identification.

We will not dwell longer upon this size world, nor upon those which lie still lower in the scale, than to point out that as the size of the particle diminishes and, as a consequence, the proportion of the surface area increases, new and unfamiliar properties are encountered and the old familiar ones lost. For example, the next size world below that of bacteria is perhaps the world of colloid chemistry. In this world particles are too small for us to see even with a microscope, but if we could see them they would probably be found to be perfect spheres and all look much alike. The properties which distinguish colloids are mainly those which have to do with surface areas, for truly this is a world of enormous surface areas.

A consideration of objects and organisms of these different size classes furnishes a suitable background against which to view pollen grains. Their most striking and fundamental characters are those of the size class to which they belong, and do not lend themselves to ready comparison with objects of other size classes. And underlying this is the old familiar law which says that the surface or cross-sectional areas of an object are functions of the square of its linear dimensions, while its volume is a function of the cube of the same dimensions.

## ECLIPSES AMONG ANCIENT AND PRIMITIVE PEOPLES

By Dr. BIREN BONNERJEA

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SCIENTIFIC researches teach us how to predict solar and lunar eclipses as they also tell us why and how eclipses are caused, but the primitive man laughs at such simple explanations and shakes his head; he knows better than to place his reliance on such fantastic explanations as the scientists would have him believe. No, the true reason for these phenomena is to be looked for elsewhere.

Primitive man peoples the universe with a host of malevolent beings whose chief delight in life is to frustrate the hopes and aspirations of poor mortals, their enemies. The earth, the sky, the waters, nay, even the trees in the forest and all things that the earth contains, has its own particular demon, always ready to swoop down and do whatever damage it can do to human beings. How numerous these demons are it would be impossible to mention in a limited space. Sir James George Frazer, in the twelve volumes of his "Golden Bough" and in other writings, has collected a mass of data from all parts of the world, and a perusal of his works convinces us that these demons are not the exclusive property of any one race, but was, and perhaps is even to-day, the common heritage of mankind.

In the book of Genesis we read: "And God made two great lights, the greater light to rule the day, and the lesser light to rule the night." The lesser light, the moon, has been the favorite theme of poets all over the civilized world; but the greater light, the sun, inspires life. It does not need a physicist to make a man realize the benefits of sunlight and the warming rays. Man seeks these intuitively. When Alexander the Great

asked Diogenes what he could do for the philosopher, the latter remarked, "Step aside, and do not shut out my sunlight."

The beneficial effects of the rays of the sun were recognized very early in human history. It was natural, therefore, that some demon would try to shut out the health and life-giving rays, and thus cause a solar eclipse; and perhaps identical ideas actuated these demons to cause lunar eclipses. Various superstitions too are attached to eclipses. The belief that eclipses are caused by demons or beasts devouring the luminaries is to be found among the Chinese, the Hindus, the Greenlanders, the Finns, the Lithuanians, the Moors, many North and South American Indians and many of these examples have been vouched for by no less an authority than Grimm.

In the cosmogony of many peoples the sun and the moon are husband and wife, brother and sister, father and daughter and so on. When these luminaries are eclipsed it is because the husband and wife are quarreling or are having some domestic disputes. Among the Mbocobis of South America the moon is the man, and the sun, his wife. An Ottawa story describes the sun and the moon as brother and sister. Among the Egyptians Osiris and Isis were the sun and the moon, brother and sister, husband and wife; among the Incas, according to Lehmann-Nitsche, the sun was the man and the moon a woman, but no kinship existed between them. In England and in France the sun is the man (Eng. *the sun*, m., Fr. *le soleil*) and the moon is the woman (Eng. *the moon*, f., Fr. *la lune*); whereas in Germany the reverse is true (*der Mond*, m.,

die Sonne, f.). To these we may add Sp. *el sol*, m., *la luna*, f., It. *il sole*, m., *la luna*, f., Port. *o sol*, m., *a lua*, f. and many others too numerous to mention. The Arapaho believed that the moon was the brother and the sun the sister, and the same belief is found among the Menominee. In the extreme south the Onas regarded the sun and the moon as husband and wife, and the neighboring Yahgans think that the moon is the wife of the rainbow, but the sun is the elder brother of the moon and Venus. According to the mythology of the *Kojiki* the "moon-deity" is a male deity, but the common Japanese people who are unable to read the *Kojiki* address this deity as *O-Tsuki-San*, "Lady Moon." The Australian natives believe that the moon is a man and the sun a woman. The Greenlanders were of opinion that the sun was a man who was amorous at certain times, and hence they took measures to protect their women from the sun; and going south among the Hindus of Bengal we find that "*les jeunes filles non mariées craignent de sortir dans la lumière du soleil, particulièrement après la période de menstruation, de peur d'être fécondées par ses rayons.*" Among the Eskimo the sun and the moon were originally sister and brother. The examples may be multiplied many-fold, but the above will show that similar beliefs are widely distributed over the face of the earth.

Talking of eclipses Brewer writes:

Eclipses were considered by the ancient Greeks and Romans as bad omens. Nicias, the Athenian general, was so terrified by an eclipse of the moon, that he durst not defend himself from the Syracusans; in consequence of which his whole army was cut to pieces and he himself was put to death. . . . The Romans would never hold a public assembly during an eclipse. Some of their poets feign that an eclipse of the moon is because she is gone on a visit to Endymion . . . a very general opinion was and still is among the barbarians that the sun or moon has been devoured by some monster, and hence the custom of beating drums and brass

kettles to scare the monster. . . . The Chinese, Lapps, Persians, and some others call the evil beast a dragon. The East Indians say it is a black griffin. . . . The notion of the ancient Mexicans was that eclipses were caused by sun and moon quarrels, in which one of the litigants is being beaten black and blue.

Similar beliefs and customs are known in the Old as well as in the New World. Below are given some of these beliefs as they are found in the different continents.

#### EUROPE

The Norsemen fancied that on the occasion of an eclipse the Mânagarmar or the moon-dog had already got a part of the shining orb between his jaws. The Esthonian explanation of these phenomena was very similar; the sun or the moon was being eaten. In Great Britain, the Irish and the Welsh run about beating kettles and pans during eclipses with the avowed intention of frightening the demon away. In the German provinces of Hessen and Westphalia, during an eclipse, poison is said to fall from heaven; hence cattle must be herded, wells kept covered and other necessary precautions are taken against any possible danger from this source. Identical beliefs are prevalent in Swabia. The Bavarian peasants too are firmly convinced that water is poisoned during an eclipse, and therefore they would not drink water at such a time. Thuringian peasants cover up wells and bring cattle home from pastures during eclipses of the sun and of the moon, and an eclipse is supposed to be specially dangerous if it happens to occur on a Wednesday. In certain parts of France they think that eclipses are caused by the luminary being destroyed. An eminent author relates how, during an eclipse, he heard a French peasant exclaim with deep anguish, "*Mon Dieu! Qu'elle est souffrante!*" and as an explanation pointed to the almost totally obscured moon.



## ASIA

In Arabia, according to Niebuhr, there was a belief that a huge fish pursued the planet that was eclipsed. In India, among the Hindus of the present day, eclipses are said to be caused by the demons Rāhu and Ketu. The former is a demon of a coal-black color who devours the sun, and causes a whole or a partial eclipse; he is said to be immortal, or rather his head is, because he had stolen into heaven and quaffed some of the nectar of immortality when Viṣṇu cut off his head. The latter is represented as being red in color and is the monster which devours the moon. As among the German peasants, the Hindus too believe that poison falls from the sky during eclipses. An eclipse whether of the sun or of the moon is regarded as auspicious; while if a solar eclipse occurs on a Sunday or a lunar eclipse on a Monday, the occasion is looked upon as especially auspicious. Some say that an eclipse is a time of ceremonial pollution when bathing becomes imperative.

Among the Garos, a Mongolian people of eastern Bengal, the "evil spirit Nawang is credited with being the cause of eclipses. He is said to swallow the sun and the moon. When the first shadow appears on the face of either, drums are beaten and horns blown to frighten the monster away." Among the Hindus of Southern India, if a child is born with a bodily defect, "it is attributed to the evil influence of two unlucky constellations which must have been in conjunction at the time of birth, or to some eclipse of the sun or moon that took place at that moment." The Chāmārs, the leather-working caste, believe that if an eclipse occurs during pregnancy, the woman must remain perfectly quiet, or the child will be deformed. The Todas abstain from food when they know that there is going to be an eclipse of the sun. But when there is a lunar eclipse they think that it is caused by a snake going

to catch a hare which has taken refuge in the moon; the moon becomes dark in order to protect her protégé. During lunar eclipses some people fire guns and send up rockets and shout.

The Cambodians believe that eclipses are caused by monsters biting the luminaries.

A Mongolian has it that the gods wished to punish the maleficient Arakho for his misdeeds, but Arakho hid so cleverly that their limited omnipotence could not find him. The sun, when asked to turn spy, gave an evasive answer. The moon told the truth. Arakho was punished, and ever since he chases the sun and moon. When he nearly catches either of them, there is an eclipse, and the people try to drive him off by making a hideous uproar with musical and other instruments.

In China a solar eclipse forebodes an ominous future. At the time when an eclipse of the sun was foretold for the Chinese New Year's Day (A. D. 1850), Taokwang was so overcome by the dread of this combination of time that he ordered the New Year's Day to be postponed for twenty-four hours. They run about making a dreadful noise during eclipses so that the demon causing them may desist. In Sumatra, Marsden informs us, "during an eclipse they made a loud noise with sounding instruments to prevent one luminary from devouring another." Among the Semang eclipses are believed to be due to the attempt of a gigantic dragon or serpent to enfold or swallow the obscured luminary. In the case of the moon, it is the moon's own mother-in-law attempting to embrace her daughter-in-law, whereas in the case of the sun the attack is in deadly earnest. The Sakai too believe in a Rāhu. The Mantras believed the moon to be married to Moyang-Bertang, the man who lives in the moon and is visible as "moon-spots." The stars are her children. The sun and the moon agreed that if all the stars were left, there would be too much light for human beings; so it was decided not to have all

the children. The sun did as was agreed upon, but the moon did not. For this breach of agreement the sun naturally was incensed, and since that time periodically attacks the moon. Whenever the sun gets near enough to the moon to bite the orb, there is a lunar eclipse.

The Filipinos believe that eclipses are caused by a monster attempting to devour the moon; they too therefore resort to the ubiquitous practise of making a noise so that the demon may be frightened. When the sun and the moon were eclipsed, the Tahitians thought that they were copulating. Among the Polyynesians some "imagined that in an eclipse, the sun and the moon were swallowed by the god which they had by neglect offended. Liberal presents were offered, which were supposed to induce the god to abate his anger, and eject the luminaries of day and night from his stomach."

In Australia an eclipse of either the sun or the moon is looked upon as a terrible calamity and as a sure portent of disease and death. The Arunta associate a solar eclipse with evil magic; their usual belief being that some evil spirit is trying to eat it up. They therefore, start throwing spears during eclipses, for that drives away the evil spirit which has come in front of the sun or the moon.

#### AFRICA

Among the ancient Babylonians and Assyrians eclipses had diverse significations. Thus it indicated an overthrow of kingdoms, flood, death, famine, miscarriage of women, revolt, rain, pestilence, war and so on. On the other hand, it also portended easy delivery of women, good crops and other equally good results. Among the Wa natives of East Africa eclipses of the moon are believed to be caused by that luminary fighting with the sun. The Wayao run hastily to fetch hoes and axes, and strike them against each other, looking up at the scene of strife and calling out, "Go asunder, go asunder, sun and moon, you

have seized one another. Go asunder, go asunder now." They observe the same customs during solar eclipses. Some Berber people believe that an eclipse is caused by a fight between the sun and the moon.

#### NORTH AMERICA

The Eskimo of the Lower Yukon think that "a subtle substance or unclean influence descends to the earth during an eclipse, and if any of it is caught in utensils of any kind it will produce sickness. As a result, immediately on the commencement of an eclipse, every woman turns bottomside up all her pots, wooden buckets and dishes." Among the Eskimo around Bering Strait a lunar eclipse is said to foretell an epidemic or war. The length of the duration of the eclipse is believed to indicate the severity of the visitation to follow. Some North American Indians thought that the moon was eclipsed "because she held her son in her arms, which prevented her brightness from being seen." The husband of the moon, they said, was the sun, and solar eclipses were caused "because he also sometimes takes the son which he has by the Moon, into his arms." The people of Nootka Sound attributed eclipses to the luminaries being pursued by a great eod fish. Among the Tlingit when the moon was darkened during an eclipse they blew out toward it to blow out sickness. The Tlascaltees regarded the sun and the moon as husband and wife; eclipses, they averred, were mere domestic quarrels. During eclipses the Kwakiutl burn old stuff that gives off a bad smell. They think that eclipses are caused by the sun or the moon being swallowed, and the burning of the evil-smelling stuff is intended to liberate the sun. Among the Tillamook nobody was allowed to look upward during an eclipse. If a person had to leave the house, he must look down on the ground. It was believed that the killing of a person strong in magic caused

an eclipse, and every vessel in the house was turned over so that his blood should not drip into it.<sup>1</sup> Among the Coeur d'Alène lunar eclipses are said to be caused by the moon covering the face or eyes. Skinner tells us that the Menominee regarded eclipses as presaging some dire calamity, so the warriors would fire at them to ward off the danger. And according to Le Jeune an almost identical custom was known among the Hurons. During eclipses the Chilcotin Indians walk in a circle, leaning on staves, apparently to assist the laboring orb. The Navaho Indians thought that the influenza epidemic of 1918 was caused by the solar eclipse which took place on June 8.

The Choctaw attributed solar eclipses to a black squirrel which tried to eat up the sun at different intervals; whenever the squirrel attempted to make such a meal, they made as much noise as possible by shrieking, beating on pans, firing guns, and so on. "But the din remained unabated until the sun again appeared in its usual splendor, and all nature again assumed its harmonious course." Those of Bayou Lacombe have a different explanation; they say that the sun walks every day, and hence he becomes dirty and smoked from the fire which is within him. It therefore behooves the sun to clean himself, after which he shines all the brighter. During the eclipse he is removing the accumulated dirt. They have a similar belief with regard to lunar eclipses. Of the Cherokee one of our older authorities, Adair, writes:

The first lunar eclipse I saw after I had lived with the Indians was among the Cherokee, An. 1736, and during the continuance of it their conduct appeared very surprising to one who had not seen the like before. They all ran wild, this way and that way, like lunatics, firing their guns, whooping and hallooing, beating kettles, ringing horse bells and making the most horrid noises that human beings possibly could. This

<sup>1</sup> F. Boas, "Notes on the Tillamook," *University of California Publications in American Archeology and Ethnology*, xi, p. 9, 1923.

was the effect of their natural philosophy and done to assist the suffering moon.

Among the Creek Indians, when the sun or the moon was eclipsed, they thought that a great toad (*sabakti*), or pig, was about to swallow it; "and in order to help drive it away they discharged their guns at it and shot at it until they 'hit' it." According to other versions it was either a big dog or a frog which caused the eclipse.

The Assiniboin think that eclipses are caused by a hand, cloud or some other thing shadowing the moon. Eclipses portend great calamities, such as war, pestilence and famine. The Cocopas think that solar or lunar eclipses are caused by the great lizard (*kwachul*) devouring the luminaries. They thought that the dream of a lunar eclipse meant that enemies would soon kill them; the dream of a solar eclipse was a portent of success against the Yuma and was an incentive to campaign. "Moon on Cocopa side, sun on Yuma side." The Yumas think that a lunar eclipse is occasioned because a certain species of lizard, called *wasany*, is eating the moon. At eclipses the Juaneño shouted and made all possible sorts of noise to frighten away the monster which was thought to be devouring the sun or the moon. Kroeber says that it is probable that the custom was universal in California. Among the Shasta an eclipse of the moon is said to be due to the dog that follows the moon eating it up. People talk, therefore, to the dog, entreating it to desist, and howl and shout to frighten it away. Whenever there was a lunar eclipse the Alsea Indians shouted out loud, "Do you come out inside; the moon is now killed." They said that "the crow usually kills the moon, and also the eagle, and likewise (from) inside; do you come out (from) the chicken hawk and, moreover, the owl." During a solar eclipse which, they said, was caused by the sun being killed, "they upset all buckets and

poured out the water because it was not desired that the water should become bloody when the sun was killed." If the Cahuilla ate during an eclipse, they were likely to eat a "moon-spirit." Whoever died during an eclipse was thought to have eaten one of these "moon-spirits." According to the Luiseno the "eclipse of the moon is the physical manifestation of Ouiot's sickness when he counted the months expecting to die. When the eclipse clears off, Moyla, Ouiot, gets well again."

Among the Southern Diegueño both young and old shoot during eclipses; they believe that eclipses cause sickness. During solar and lunar eclipses the San Luis Rey Indians shouted and made noises by clapping their hands. "On being asked the reason, they have always answered . . . that they believe that an animal was trying to eat the sun or the moon, and that they did these extreme things in order to frighten him, thinking that if he ate them they would all perish." The Indians of San Juan Capistrano believed the same. Among the Serrano the first person who saw an eclipse of either the sun or the moon raised a shout which was taken up by everyone. Eclipses, they thought, were caused by the spirits of the dead, "who were believed to be eating the dark portions on which the shadow fell." They would not touch any food while an eclipse was in progress; any one doing so would be assisting in the eating of the sun or the moon.

#### CENTRAL AND SOUTH AMERICA

The ancient Mexicans thought that a solar eclipse was caused by a jaguar eating the luminary; and it was a common superstition among the Mexican women that children born during an eclipse would be turned into mice. The ancient Aztecs were careful that a pregnant woman should not see an eclipse, or her child would be metamorphosed into a rat or have some physical defect, such as a

harelip. This belief persisted in Mexico as late as the nineteenth century. The danger, however, was nullified if the woman took the simple precaution of wearing an obsidian knife over her bare breast. In the state of Oaxaca it is still believed that pregnant women looking at a lunar eclipse will give birth to a harelipped baby; they think that eclipses of the moon are caused by the luminary being burned ("*porque la luna se está quemando*").

The Yucatan Indians explained lunar eclipses by saying that either the moon was dying or that the orb was being bitten by a certain kind of ant called *xubab*. Talking of eclipses, Pedro Sanchez de Aguilar writes: "*En los eclipses de Luna [they] usan por tradicion de sus passados hazer que sus perros aullen, o lloren, pellizcandoles el cuerpo, o las orejas, y dan golpes en las tablas, y vancos, y puertas.*"

The Caribs believed in a demon called Maboya, a hater of all light, who caused eclipses by devouring the sun or the moon. Maboya is said to have had the power of sending hurricanes, and is recognized as a sky god. In Cayenne eclipses are caused by monsters eating them; if the eclipse is total or of short duration they consider it a fatal thing for them. The Garifs regard an eclipse of the moon as being caused by Máfya, which no doubt is merely a dialectic form of Maboya.

During a solar eclipse the Arawaks rushed from their houses with loud shouts and yells, explaining that a fight was going on between the sun and the moon, and the shouting was to frighten and so part the combatants. The Chiquitos shoot arrows upward, and cry aloud to drive away dogs, who, they believe, hunt the moon through heaven; when the dogs overtake the luminary, the darkness of the orb is caused by the blood which runs from her wounds.

Among the Orinoco tribes lighted brands are carefully put away under-



ground during an eclipse of the moon; they thought that if the moon were to go out, all fires on the surface of the earth would also go out. At such times they seized their hoes and labored with exemplary vigor on their growing corn, saying that the moon was veiling herself in anger at their habitual laziness. The Sumu believe eclipses, both lunar and solar, are caused by a jaguar eating the luminary; hence they attempt to frighten the feline away by shooting arrows at it, making great fires and beating drums.

The Cuna Indians of Panama believe eclipses are caused by a demon—half dog, half woman—which starts eating the luminaries; they shoot at it with miniature arrows to make it desist. In Guarani belief eclipses are caused by “a jaguar and a great dog, which pursued the sun and the moon to devour them.” The Uaupés Indians think that lunar eclipses are occasioned by the demon Yurupari killing the moon; hence they too frighten the demon by making a hideous noise. To give one more South American example we may mention the Kutašo of Brazil, of whom very little is known. They thought that every time the moon had a miscarriage, an eclipse resulted.

#### CONCLUSION

From the above survey, embracing as it does the whole of the habitable globe, we see that a large majority of peoples believed that eclipses were caused by the luminaries being threatened by some danger to their existence, and that this danger commonly took the form either of a demon or of a ferocious beast; the nature of the beast depended upon the climate and environments, and this beast has been variously described as a dog, a fish, a squirrel, a pig, a toad, a frog, an ant, a lizard and a jaguar. Considering, however, that means of communication were yet in their rudimentary stage among the primitive peoples, and

considering the wide prevalence of the belief, it immediately becomes apparent that such beliefs could not have been borrowed, and that they must have had independent origins. Rudiments of science existed among all peoples no matter how low they might have been in the evolutionary scale.

The fact observed during eclipses was the dimness of the otherwise bright orb, and the natural solution which came to the mind of the primitive philosopher was that the dimness could have been caused by one of two reasons—either the orb was hiding, or that it was being destroyed. In the former case it was caused by shame. In the latter case, the only reasonable thing to suppose was that such destruction could take place only through the intermediary of a being mightier than the orb itself, and what could be more logical than to think that such a being was a demon or an immense beast?

Primitive man also noticed that eclipses were never permanent; hence the phenomena were explained by saying that the demon had to set the orb free, and they tried to hasten it by noises, shooting, and so on. The superstitions connected with eclipses all show that there is a general fear of being poisoned at such a time, and perhaps a typical one of these beliefs is that recorded of the Tillamook by Professor Boas.

Exact knowledge can only be gained by experience. Progress has necessarily been slow, and humanity has passed through stages the beginnings of which extend back to the hoary past—in magic. A study of any set of beliefs will show the same trend in reasoning through which man has passed on his road to civilization. There is much to be learned yet, and the longer we live, the better we realize how right Freud was when he said: “The man of prehistoric times lives on, unchanged, in our Unconscious.”



# SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

## IS AMERICA ABOUT TO LOSE HER ELMS?

By Dr. STANLEY B. FRACKER

IN CHARGE OF THE DIVISION OF DOMESTIC PLANT QUARANTINE, U. S. DEPARTMENT  
OF AGRICULTURE

DURING the past generation, America has watched helplessly while the centuries-old chestnut forests of the East have been wiped out by an imported Asiatic disease. North of the Carolinas little now remains of the extensive stands of that valuable tree except thousands of gaunt, bare skeletons standing dead in great stretches of forest in the Appalachian range.

A similar forest tree disease known as the "Dutch elm disease" attacking elms was found last year strongly established in parts of New Jersey, New York and Connecticut. This disease was no stranger to us, for Americans have been watching with alarm the spread of this tree plague in Europe since it was found and described in 1919. No one knows what part of the world it originally came from or exactly when it reached Europe, but from the time it was discovered in Holland sixteen years ago it has swept east and south across Europe and west and north into the British Isles and has destroyed elms as it progressed. The rapidity with which it works and the suddenness with which the affected trees die, are quite without parallel among the diseases of forest and shade trees, with the exception of the already disastrous chestnut blight.

Beautiful shade trees in the most conspicuous places are among the favorite victims. The majestic rows of elms in the Versailles Park at Paris have been killed and taken out. Two thousand elms were destroyed in the Bremen district of Germany in 1930. Elms bordering the stately avenues of Bucharest,

Hungary, and Vienna, Austria, found dead and dying, have been removed, and recent newspaper reports describe the destruction of the elms on the grounds of the Windsor Palace in England. In Rotterdam, Holland, in 1930, 17,000 elms were said to be killed by the disease, more than half of all the elms in the city. In the city of Baarn in Holland all the elm trees are reported to have been killed by 1930. Along the highways and canals and in the woodlands of the same countries, similar results have followed the introduction of this disease.

It was hoped that this tree plague could be kept from getting into America, and every effort was made to prevent its introduction. In spite of this attempt, the disease was found in New Jersey in June of last year and a few weeks later several cases were discovered in parts of New York and Connecticut. By the middle of last December over 800 trees were dead or dying of the Dutch elm disease in those three states, and diseased and infected trees are being found so rapidly this summer that the number found to be doomed from the disease is now about 6,800.

About the same time that the disease was discovered in New Jersey, the department learned that one way through which it was reaching this country was the importation of burl elm logs for manufacturing veneer for furniture. An examination of burl elm logs arriving from abroad last year showed that they had come from infected trees. As soon as that discovery was made the

further introduction of the disease in that manner was stopped by quarantine action. Plant quarantines were already preventing the importation of elm nursery stock.

The Dutch elm disease is caused by a fungus growing in the young sapwood. After getting into the tree this fungus grows rapidly and in the course of a few weeks or months the leaves wilt or turn yellow. Sometimes this wilting and yellowing is confined to a single branch and sometimes the entire tree seems to be affected at once and may die completely within two or three weeks after the first symptoms are seen.

So far as has been learned from experimental work, the spores or germs of this fungus do not seem to be carried by the wind or rain from one tree to another. It is thought they are introduced into healthy trees by small bark beetles. These beetles prefer weak, diseased or dying trees as places in which to lay and hatch their eggs, but unfortunately instead of feeding only on such weakened and sickly trees, the adult beetles get their food supply by feeding on the bark and twigs of the healthy elms. When they do this, it is believed they may introduce the fungus which causes Dutch elm disease and are thus able to spread the disease with such alarming rapidity.

There are other fungous diseases with similar symptoms attacking elms, but they are not as serious. The wilting and yellowing of the branches in the case of some of the other diseases very closely resemble the symptoms of the Dutch elm disease and some of them also show brown streaks in the sapwood, a striking characteristic of the Dutch elm disease. These fungi, however, do less damage, because they do not spread rapidly and the trees can frequently be saved by the removal of infected branches.

It is therefore a matter of the utmost importance to be able to determine positively whether an elm showing wilting and yellowing branches is infected with

the disastrous plague known as the Dutch elm disease or whether it is only being attacked by one of the less harmful fungi. A special laboratory for this purpose has been set up by the department at Morristown, New Jersey. At this laboratory every specimen sent in is carefully examined and cultured and a definite diagnosis made. This is done not only for all the specimens sent in by the scouts in the infected areas of New Jersey, New York and Connecticut, but in the case of all specimens sent from other parts of the United States. Many such specimens from other parts of the country are being received, but none of them so far this year show the Dutch elm disease, except those from the known infected parts of the three states named.

Collecting specimens of diseased twigs is sometimes difficult. If the tree is small, samples may be taken from the ground by the aid of long-handled pruners. If the tree is large it must often be climbed, usually with the aid of ropes. Climbing irons such as are used by telephone linemen are injurious to the tree and can not be used on valuable trees. Several segments of branches about the size of a lead pencil or slightly larger taken from the affected part showing brown streaking in the sapwood usually constitute suitable material.

Once a tree is diseased there is no way of curing it. Last year some of the owners were anxious to save valuable elms when possible and in a number of cases only the wilting and yellowing branches were cut off in the hope of saving the trees. This has not proven effective, for the following year the rest of the tree usually succumbed.

The only practicable basis of safeguarding the healthy elms is a complete eradication of the disease by searching out and destroying the infected trees before the disease spreads to other trees. The obvious symptoms of the disease in a tree are evident during the growing season for six to ten weeks before the bark

beetles in the bark can mature and emerge to spread the disease. This makes it possible to locate and destroy the affected trees and thus prevent its dissemination by these beetles. It is evident, therefore, that if the disease is principally transmitted by these bark beetles, as is now strongly indicated, eradication is both practicable and feasible, providing the required work is done promptly and persistently.

The eradication of infected trees is often a difficult and costly problem. Street trees and trees near houses have to be removed in small sections and the sections let down by ropes. Prompt destruction of all the wood and bark of the diseased tree is required and this adds greatly to the cost of eradication. Elm wood is very heavy and must be sawed into short lengths for handling or else handled by the use of expensive and cumbersome machinery. In some cases even the latter can not be used to advantage because of the location of the tree against buildings, etc. The main purpose in diseased tree eradication is lost if the work is not completed before the bark beetles mature and emerge, thus spreading the disease to healthy trees. The green, wet and soggy wood is heavy to haul, and it can not be burned without the application of fuel oil, and constant tending of the fire is necessary in order to secure complete destruction. In the present eradication work the tree is sawed off near the ground line and the bark is removed from the stump. The stump is then heavily treated with creosote or other suitable fungicide.

Beginning in 1930, three years before the New Jersey outbreak was discovered, a number of infected trees were found in Ohio and last year one small tree was found in Maryland. Apparently the Dutch elm disease can be entirely eradicated in those states. This was a comparatively simple task, as it seems that the bark beetles which are concerned in the spread of the disease have

not reached Ohio and Maryland. These beetles are found only in an area which extends from Philadelphia, northeast through southeastern New York and New Jersey to New England, as far as northeastern Massachusetts.

The present stage of the Dutch elm disease eradication work is that every elm in the infected area of some 3,000 square miles within approximately 25 miles of New York Harbor has been visited twice this summer and specimens of twigs have been taken in case there were any indications of wilting or yellowing foliage and brown streaks in the wood. In another belt almost 15 miles wide, completely around this central infected area, all the elms have been examined once. The employees of the U. S. Department of Agriculture on this project are now working in this outside zone, for it is exceedingly important to get out all these outlying trees farthest from the infection center before the disease can spread to greater distances. In the meantime the authorities of the three states concerned, together with the local groups, are directing all their resources to an attempt to cut down the trees in the infected area before the beetles can spread the disease from them. State and local funds unfortunately have, until the last week or two, been so limited that the state authorities had been unable to keep up with the new trees being found from day to day, and they have gotten far behind. It appears now that when fall comes some 1,500 to 2,000 diseased trees will still be standing, a menace from which the Dutch elm disease may again sweep outward next season. Past years' investigations have shown that in cases where diseased trees can not be destroyed promptly, the infection spreads to about six times as many trees the following year.

It is clear, therefore, that the battle is very far from being won and that if America is to keep out the infection and save her elms, the contest will have to be

fought next year even more vigorously than it has been this season. Neither is the fight entirely lost, for thousands of the diseased trees have been promptly destroyed, and probably hundreds of thousands of the little bark beetles which are believed to spread the disease have been prevented from carrying it to the other elms in the vicinity.

This country has proven in other similar campaigns that a new plant disease or a new insect arriving within our midst can be completely wiped out, if the

effort is vigorous enough and the resources adequate for the job on hand. We believe that the Dutch elm disease can be eradicated from the United States and the elms of America protected from the disaster which has overtaken those of Europe if the diseased trees of the New York, New Jersey and Connecticut area can be found and destroyed fast enough and if the work can be continued until the last trace of this fungus is destroyed.

AUGUST 15, 1934

## ALONG DARWIN'S TRAIL IN SOUTH AMERICA

By Dr. WILFRED H. OSGOOD

CURATOR OF ZOOLOGY, FIELD MUSEUM OF NATURAL HISTORY

A FEW years ago I spent some months with a party in search of animal life in southern South America—Chile, Argentine and Patagonia. This region is far beyond the Equator, in the south temperate zone, where the climate is much like our own, and there are no dangerous tropical diseases, no poisonous snakes, and no blood-thirsty lions or tigers. The animals that do live there are not widely known and the number of species is not large, but among them are some of great peculiarity and much interest.

The route followed took us down the west coast of South America to many of the localities visited by Charles Darwin on his famous "Naturalist's Voyage Around the World" and we had the pleasure of rediscovering, so to speak, many of the animals originally found by him a hundred years ago. Darwin was only 23 years old when he started on this great journey, and in the five years of continuous field work which followed, he laid the foundation for much of his later study. He not only proved himself to be a wonderfully accurate observer and a profound thinker, but also an energetic collector of natural history specimens. His collections in all branches of

natural history subsequently furnished the basis for numerous scientific studies not only by himself but by various specialists, including many of the greatest zoologists, botanists and geologists of that time. Darwin's specimens, in this way, became standards of comparison and even now a great part of our knowledge of the natural history of southern South America is based on them. Therefore, the special student whose problems enter this field has been obliged to go to London to examine them. This was not always convenient and would not be necessary if duplicate specimens were in American museums. To get such duplicate specimens, therefore, was one of our objects.

During the voyage we made many short stops and saw much of interest, but most fascinating to naturalists were the great flocks of sea birds off the coast of Peru. These are the birds of the famous guano islands—cormorants, pelicans, gannets and a few other species—all birds of large size, strong flight and fish-eating habits. They are in such numbers that one scarcely believes his eyes and wonders how there can be fish enough in the sea to feed them. One

morning our ship was anchored in the midst of them and air and water were alive with birds in all directions. Long curving lines of cormorants stretched from one horizon to the other, an endless stream of flying birds forming a dark band just above the water and dividing the full expanse of the ocean. Nearer by, they lay in black rafts covering acres and acres on the water, while over them pretty white gulls wheeled and turned gracefully. Above our heads were flying birds in numbers only comparable to a swarm of gnats, but these were gannets, each as big as a small goose. They were engaged in fishing, falling like plummets all about us to hit the water with a chug and a splash and then rising to try again. Thousands were striking the water at once so it was covered with little spurts of spray as if receiving a rain of shot. Why a rising bird in such a *melée* never collided with a falling one was a mystery. It was a wonderful sight and probably could not be duplicated anywhere else in the world.

After landing in central Chile, which reminded us much of central California, we passed quickly southward to the islands of southern Chile, where we found heavy forests and a cool, moist climate. In this region northern and southern animals meet, and at one of our camps we were able to stand on shore with flocks of parrots screaming over our heads, and hummingbirds buzzing about them, while out on the water schools of penguins were playing. To a naturalist, this is very paradoxical, like finding Eskimos and Hottentots inhabiting the same island, for parrots and hummingbirds are usually tropical birds, while penguins are characteristic of the Antarctic region. The Chilean penguins belong to one of the small species known as Jackass penguins, a name applied because they have a call that suggests the braying of a mule. Their northward distribution on this

coast is due to the cold Humboldt current.

One of the animals discovered by Darwin was a small, dark-colored fox from the island of Chiloe. In his book he relates that while walking on the shore one evening he saw a fox sitting on a point of rocks and so intently watching something in the distance that he was able to creep up quietly behind it and knock it on the head with his geological hammer. Since Darwin's time it had not been taken again, and I was anxious to secure a specimen, so I made inquiries about it as soon as I reached southern Chile. My first informant had lived some years on Chiloe Island and was well acquainted with its animals. Moreover, he had a Spanish edition of Darwin's book. When I mentioned the fox he threw up his hands exclaiming, and with true Latin politeness and delicacy stated that he had no desire to question the veracity of a great English scientist like Darwin, but that fox story was more than he could swallow. He had never heard of a fox on Chiloe Island, and even if he had, how could he be expected to believe that a man could walk up to one and kill it with a hammer! His arguments were good, but they only made me the more anxious to test the matter myself, so when I reached wilder parts of the island, I began immediately to look for fox tracks and soon found what I thought was at least one in the sand of a small beach. Knowing that foxes are often habitual beach combers and fond of fish, I set traps very carefully in the woods at each end of this beach and baited them with tempting fresh fish. The very next day I had a fine fox and two days later another, so Darwin's reputation was saved. It was saved at least so far as the existence of the fox is concerned, but that story of killing it with a hammer is another matter. Possibly it ought to be brought to the attention of the anti-Darwinians.



Perhaps the most attractive animal we found on Chiloe Island was the tiny deer which the natives call the pudu. It is the smallest of all the true deer. It stands about 17 inches high at the shoulders, weighs about 22 pounds when full grown, and has little spikes of horns just three inches long. The African dikdiks and the East Indian mouse deer are a little smaller, but they are not true deer. The pudu lives in the tangled depths of the forest where its narrow winding trails are too small to be followed by the hunter, so it is practically impossible to get one by shooting. When pursued by dogs, however, the little deer take to the water, where they can be overtaken by boats and lifted out alive. In this way we obtained several live ones and greatly enjoyed keeping them as pets in camp. The pudu has all the grace and attractiveness of the larger deer, with an added touch of daintiness which is given by its small size. Altogether it is one of the most attractive and lovable animals I've ever met. It is fairly well known to the Chileans, but has rarely been seen outside that country.

One of the more common and widely known animals of southern Chile is the coypu or nutria, an important fur-bearing animal. Its habits are amphibious, somewhat like those of the muskrat, but it is as large as a beaver and is sometimes called the South American beaver. In fact, if it were not for its long, round, ratlike tail, it would look very much like our northern beaver. Its fur when plucked and prepared also resembles beaver but is inferior to it. The fur is quite well known under the name nutria and is used extensively in this country. The females have an extraordinary adaptation for life in the water. The milk glands and nipples are not on the breast but on the back near the middle line, making it possible for the young to nurse while the mother is swimming about or floating on the water. In this

remarkable adaptation it is unique among mammals. We had a live coypu in camp for some days and found the only thing it would eat was potato. The west coast of South America is the original home of the potato and there are various kinds of wild ones growing in Chile, so perhaps this is the explanation of the coypu's taste.

There are no more snakes in southern Chile than in Ireland, but frogs and toads are numerous. Among them is one with peculiar breeding habits. This little frog was also discovered by Darwin and is now called Darwin's frog. It is a tiny little chap scarcely more than an inch long, bright green in color, and it has a sharp little proboscis on its nose. In this species the eggs, after being laid by the female, are picked up by the male and held in his mouth or in a pouch in his throat. He carries them here until the fully formed young are hatched, for in this frog there is no tadpole stage. As the embryo frogs develop, the pouch extends backward between the skin and muscle of the abdomen until it occupies the whole abdominal area, giving their father, who acts as sort of brooder, a very bloated appearance. Meanwhile, the female parent, the mother, has no further responsibility after having produced the eggs.

From the wet forests of the Chilean coast, our party crossed the mountains to the eastward and came out on the open grassy pampas of Patagonia, much like our western prairies. Here we found ourselves in an entirely different world of animal life. Although it may seem strange, animals are more numerous on the pampa than in the forest. Most conspicuous are the water birds—ducks, geese, swans, snipe, plover, divers and waders, which occur in flocks and can be seen for long distances. There are many small ponds scattered over the pampa and, especially near the base of the mountains, numerous springs of

clear water surrounded by great areas of open swamp which furnish ideal feeding and nesting conditions for these birds. Geese, which are mostly white in color, are found by thousands, tens of thousands and even hundreds of thousands. As they sit close together on the level plain they look like great patches of snow. Much more beautiful than the geese are the stately black-necked swans, one of the finest of all birds. They are not found everywhere in the pampa, but are common enough so that in a few weeks' time we saw a total of several hundred. Domesticated swans in city parks are always pleasing, but wild swans in a wild setting, seen by stealth and usually from concealment, never fail to fascinate as one of the most charming sights in nature.

A bird which gave an especial thrill when first sighted was the southern or Andean flamingo. Under warm skies with the lazy serenity of tropical seas and palm-bordered islands, flamingoes usually provide an unforgettable feast for the eye, whether to ornithologist or layman. In bleak Patagonia they were no less entrancing. Like the penguins on the coast, they seemed curiously out of place, and this impression was heightened by encountering them late in the season when the chilly blasts of approaching winter were beginning their famous "roaring." Once a flock of nearly a hundred was seen under especially captivating circumstances. Our small party was returning from a hard day's ride, tired, chilled and buffeted by fierce winds. Leaving the pampa we began threading about in adjoining foothills just as a squall broke with a heavy fall of snow. As we topped a small rise, a circular basin lay just below us containing a shallow lake where a flock of flamingoes was enjoying protection from the wind. We stood for a moment transfixed while the pink-bodied, stately birds hesitated. Then they rose and wheeled

about us with the brown hills as a background and the great white flakes of snow pelting against their soft-colored forms. A sudden burst of light from the west fell on the scene and the birds disappeared in the flying snow leaving us with a lifetime memory.

Besides the water-birds, the most interesting bird of the pampa is the rhea or South American ostrich. This is quite common and as many as 40 or 50 may be seen in a single day's ride. It is said that the story of the ostrich's hiding its head in the sand is not strictly true, but our experience corroborates the idea that it is a very foolish bird. On our first ostrich hunt, we sighted one and took after it on horseback. It ran until it came to a barbed wire fence, then turned and followed the fence for about a half mile until it reached a small round corral which had been made for temporary use by sheep herders. It ran directly into the corral and then circled around inside until we rode up and easily knocked it on the head with the butt of a whip.

The principal large mammal of the pampa is the guanaco, sometimes called American camel, because it is in fact related to the camels. It is the wild stock from which the domesticated llamas and alpacas of Peru and Bolivia were derived. In Patagonia, it is still to be seen in herds numbering several hundred, much as antelope used to be on our western plains. Hunting it was rather exciting and not altogether easy. It is done mainly on horseback, and after sighting the animals, one may have to ride madly over rough country to get within range or to head them off. Although there is some demand for their hair and hides, they have not yet been hunted to the verge of extinction. Since Patagonia is unlikely to become very populous, there is hope that they may maintain themselves there for years to come.

At least one other interesting animal should be mentioned. This is the chinchilla of the high Andes of northern Chile. It was fairly common only a few years ago, but the demand for its beautiful fur has been so great that it is now very rare, and if it were not for the fact that it lives in the highest and most remote parts of the mountains, probably it would be quite extinct. It is a rodent not closely related to any northern animals, although it is about the size and somewhat the appearance of a small rabbit, with a long bushy tail something like that of some of our mountain pack

rats or wood rats. It lives in broken rock at elevations of 14,000 feet and higher. Such places, in the winter season when the fur is most valuable, are almost inaccessible and the chinchilla hunters endure very great hardships. Our experience with it was confined to observation of captive specimens in the hands of natives who are contributing to an effort now being made to introduce it into the mountains of California and elsewhere in the United States. As a wild animal it seems practically doomed, but semi-domestication may save it from total disappearance.

## SCIENCE AND THE RECOVERY PROGRAM

By Dr. A. M. MacMAHON

CURATOR, DEPARTMENT OF PHYSICS, MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO, ILL.

Looking back through six thousand years of human history, we are always impressed with almost countless trends and changes in the affairs of men. At least one trend, however, has clearly preserved its course into modern times. Much older than written records, it started with the primitive beginnings from which the home evolved. Later, from motives of protection or aggression, in one line of endeavor or another, families grouped themselves into villages and tribes. Tribes formed states, and, in time, states became consolidated into nations. Our own generation has witnessed the birth of that struggling babe, the League of Nations. Whatever our views regarding the details, we must recognize that, in the long trail that has been beaten out between savagery and civilization, the most significant trend has been a marked improvement in man's ability to get along with his fellows. Underlying this movement has been an ever-increasing realization of the existence of great general truths, known and unknown, which apply to us all, in-

dividually and collectively, and a long-tested belief in the social effectiveness of the spirit of fair play. I would relate these fundamentals to the origin and growth of scientific activities throughout the world, and, in so doing, review the part which men of science play in raising the economic status of mankind.

Nature has taught man his regard for truths, and his ideals of fair play, largely of social origin, have shown him how to develop them. Each day the sun rises, each month the moon appears in her familiar phases, each year the seasons follow in regular succession, each time an apple grows ripe and falls to the ground, brings anew the lesson of an orderly universe without which no knowledge of future value would be possible. Examples of the integrity of nature are legion, but their observation alone has not built the connected body of knowledge which we call science. It is the fair-minded comparison of observational data from all sources which leads to the discovery of the general truths so essential to their systematic

organization. Therein lies the power of science in the service of man, since it provides an expanding and already surprisingly unified view of the circumstances under which he lives. For science, like art, belongs to the whole world; before them vanish, as never before, the barriers of nationality.

The comparatively recent recognition of the scientific method of extending the boundaries of human knowledge and the rapidity with which its conscious application has met with success are of considerable importance to the understanding of a world-wide economic depression and to the formulation of remedies which may help us to avoid a recurrence. Some intuitive appreciation of the possibilities of science is probably as old as the race, but its effective organization is relatively new. For example, the ancients knew that the moon receives its light from the sun. Again, the eclipses of the sun were observed with such care by the Chaldean priests that their data have proved quite valuable to the astronomers of to-day. Centuries before the birth of Christ, the Egyptians fixed the length of the solar year to one part in ten thousand. Also, Eratosthenes, a Grecian scholar of the third century, B.C., surveyed the distance between two cities located upon the same meridian and calculated a polar diameter for the earth equivalent to 7,850 miles, within fifty miles of the value now accepted. As a rule, however, the ancient workers were isolated and but few of their meager records have been preserved. Modern science made its strong beginning only three or four centuries ago when the spread of the art of printing made it possible to give a wide circulation to detailed information. The past hundred years have brought the most rapid scientific progress in history. Where, in any one generation, the ancients numbered their scientific workers by the dozens, we now number them by

the tens of thousands. National and international groups have sprung up for the comparison of data, the exchange and criticism of coordinating ideas and the planning of future researches. Appreciation of the value of the experiment under controlled conditions has grown by leaps and bounds. Patient measurement and constant checking of data by numerous investigators have piled fact upon fact. Out of these accepted results have arisen the general truths whose vigorous influence upon the invention and development of new devices has frequently culminated in the creation of huge new industries. It is only the speed with which these things have been accomplished that has temporarily confused our powers of social and economic readjustment.

During the last century of the sixty for which major human events have been recorded, practically every activity of man essential to his physical well-being has been enlarged and markedly improved. The grain farmer, the dairyman, the truck gardener, the livestock grower, the wool producer and the cotton planter provide, or can provide, an abundance of the commodities fundamental to life. The geologist has revealed great stores of raw materials, hitherto unknown, in the earth's crust. The mining engineer secures and extracts their valuable constituents for use as fuels and materials of construction; the chemist is able, in thousands of cases, to separate them into their elements and recombine them into alloys and synthetics to suit particular needs, never before adequately satisfied. Steam and electric trains, automobiles, airplanes, huge sea-going liners and freighters give means of transportation which have made the world a neighborhood. Travel and exchange of goods go on at a rate never dreamed of in olden times. Not long were we content with the post and the electromagnetic telegraph. We must

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talk across continents and over oceans. Communication, that great leveler of man's difficulties with his remote companions, has been made swift and easy. Over the radio the Chief Executive of our government frequently reaches millions of people in a single speech. In the manufacturing industries, processes and machines have been developed not only for the economical, large-scale production of the necessities of life but also for making generally available many of the old-time luxuries at greatly reduced cost. Compare the conveniences of the average modern home with those of the Middle Ages and you have a proof. If the medical profession and the sanitary engineer have not completely eliminated plagues and pestilences from the face of the globe, they have, at least, made it a far safer place to live on and have added considerably to the comfort and average span of life.

Thus, in addition to its rôle as a great emancipator of labor, science extends human activities and enriches human existence. By pushing forward man's economic frontier—meaning, the conditions affecting the production, distribution and consumption of the world's goods—the increasing applications of science multiply, correspondingly, the number of interesting jobs all the way along the line. Look at the statistics! The twentieth century, at its worst, sees more men and women employed in gainful, healthful occupations than any previous period in man's career. As a people, we have only to master the social problems connected with the uses of the machine to obtain a freedom never widely realized in any previous epoch of the history of the race.

A freedom for what! Everywhere, the pertinent question to be asked of any new program is, principally, not how we are to profit in a material sense but whither its following may lead us. No one can predict exactly, but we can all

try; we can have an objective. Human values are almost as varied as the individuals born to live, but conserved in our democratic ideals are tremendous racial experiences, which are as much the tests of social truths as the achievements of experimental science are tests of the truths of nature. Our democratic ideals would assure every newcomer of his rights, among his fellows, to an opportunity for a full development of his talents, with a variety of social rewards, according to his merits. Free competition seems to be the best way for taking care of equality of opportunity; even the genius must acknowledge his debt to the social stimulus. We, therefore, subscribe to a form of government, known as a democracy, based upon the similarities and not the differences between men. If we so will, increased leisure time may lead to a more complete realization of these ideals for all of us, with large social and individual economies; and, if anyone doubts that the race has already traveled a long way in their pursuit, let him compare the motives underlying the economic statecraft of a Hoover, a Roosevelt or a MacDonald with those apparent in the dynastic intrigues of a Henry VIII or with the highly accentuated personal ambitions of a Napoleon. Like science, a substantial and enduring government is founded upon principles of truth and fair play. The solidarity and strength of a people depend upon how thoroughly they understand and apply these principles, always basic to their present status as well as to their spiritual and material growth.

In the advancement of democratic ideals, it is believed that a wider and more intimate understanding of scientific and industrial movements is required in the future for the proper coordination of national and international activities. All of us must become more familiar with their elementary and basic features, at least, if our efforts are to contribute



toward rather than retard the general progress. Science has provided mankind with amazing new tools and a powerful method for solving his problems. Let us learn to use them, intelligently.

Educationally, the solution is simpler than it seems at first sight. Show the public the unvarnished facts of scientific and industrial influences. Provide the opportunity for cultivating realism. Collect the masterpieces of science and engineering and operate them in an intelligible and dramatic manner. Demonstrate the principles upon which they are based. Effectively, take the people into the laboratories and factories of the past and present, supplying the human element with guides and attendants competent to aid and instruct. Let every interested person browse freely among the exhibits, many of which he may operate for himself, and absorb firsthand the story of the cotton gin, spinning wheel and loom, the forge and the steel mill, the steam engine and the electric motor, the telegraph and the telephone, the horse, tractor and automobile, the sailboat and the liner, the hut and the skyscraper. Present the fundamental phenomena of mechanics and electricity, heat, sound and optics. Show why scientists believe in atoms, the building blocks for all substances, useful and unused, animal, vegetable or mineral. Teach the strength of the picture of the electrical structure of matter; this coordinated view of the material world not only has affected numerous long-established industries but also has given rise to many new ones. Give the public a chance to understand, clearly, by personal contact, what is going on, a privilege hitherto enjoyed only by the specialist in a rather piecemeal fashion.

Natural leaders will then arise to take care of the problems which beset us. Instill in the public mind the lesson that progress has come and can only come through a willingness to make intelligent changes, and enthusiastic support will not be lacking to them.

Supplementing the work of colleges, universities and public schools, institutions designed to accomplish these purposes with full-sized operating exhibits are arising all over the world. Germany, France and England have had them for many years. In the United States, the Smithsonian Institution of Washington, D. C., the Franklin Institute of Philadelphia, the New York Museum of Science and Industry, the Ford Museum of Dearborn, Michigan, and the Museum of Science and Industry of Chicago are examples. Japan and China are making plans for similar enterprises in public education.

We may conclude with a modern version of some of the thoughts of Louis Pasteur. "If the conquests useful for humanity touch your heart, if you are inspired by the astonishing results of photography, aeronautics, radio, anesthesia, the germ theory of disease and other wonderful discoveries, if you are proud of the part your country may claim in spreading these marvelous things, take an interest in those sacred places, the laboratories of science. Demand that they be multiplied and improved. These are the temples of the future, of health, prosperity and well-being. In them humanity grows, fortifies itself and becomes better. There we may learn to read in the works of nature the story of progress and to envisage such universal harmony as it may be our lot to achieve."

# THE "LIE-DETECTOR"

By FRED E. INBAU

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Long before psychologists ever attempted to develop a scientific technique for detecting deception, persons of average intelligence must have observed the fact that conscious lying ordinarily produces certain emotional disturbances—such as blushing, squinting of eyes, squirming, peculiar monotone of the voice, throat pulsation, cold sweat and a host of other manifestations. In China there existed a practise of requesting an accused to chew rice and then spit it out for examination—and if the rice were dry the subject was considered guilty, because his fear of guilt was supposed to inhibit the secretion of saliva. In India the movement of a suspect's big toe was supposed to be an indication of deception. The courts of law in our own country sanction the consideration by a jury of many bodily activities frequently displayed by a lying witness or a guilty defendant. For instance, a judge may, with all propriety, instruct a jury that in determining the credibility which should be accorded the testimony of a defendant in a criminal case they may take into consideration his demeanor and conduct both upon the witness stand and during the trial. Moreover, the conduct, general behavior and words of a person charged with crime, about the time of its commission or its discovery or upon his arrest for or upon his accusation of it, are admissible as evidence against him. It is apparent, therefore, that the notion of detecting deception by utilizing certain psychophysiological principles is not entirely new.

In their efforts to develop an accurate and reliable "lie-detector," scientific in-

vestigators have obtained the most encouraging and satisfactory results from experimentation regarding the symptomatic changes in respiration and blood-pressure. Many years of experimentation, principally by three men in this country, W. M. Marston, John A. Larson and Leonarde Keeler, has resulted in the development of a very useful technique for detecting deception.

The instrument used for this purpose, the Keeler Polygraph (Figs. 1 and 2), consists of three units—one for recording respiratory changes; another for continuously recording the pulse wave and blood-pressure; and a third for recording a duplicate blood-pressure-pulse curve or for recording muscular reflexes of the arm or leg. (Ordinarily only the first two units are used; the third serving merely as an accessory.)

For obtaining these bodily reactions, a rubber tube (pneumograph) is placed around the chest, and a blood-pressure cuff, of the type ordinarily used by physicians, is fastened about the upper arm and then inflated to a pressure about midway between the systolic and diastolic blood pressures. Hollow rubber tubes of approximately one quarter of an inch in diameter lead from both the pneumograph and the cuff into metal tambours, to which are attached two styluses. At the tip of each stylus is a small cup which is kept filled with ink and which feeds the pens as they fluctuate with each pulse beat or respiratory movement. The recordings are made upon slowly moving graph paper driven by a small synchronous electric motor.

An instrument of this type should be distinguished from the numerous



FIG. 1. THE POLYGRAPH IN OPERATION

other so-called "lie-detectors" frequently found in the psychology departments of many universities. Usually such experimental devices consist of a galvanometer and Wheatstone bridge—an instrument for observing the psycho-galvanic reflex, that is, the changes in skin resistance when an imperceptible current of electricity is flowing through the subject's body during the period of questioning. The galvanometric change in the body serves as an extremely sensitive criterion for emotionality, but can not by itself be depended upon as a means for the detection of deception. Used, however, in conjunction with the other two reactions (blood-pressure and respiration), it may be of considerable assistance. The new Polygraph will contain this unit in addition to the others previously mentioned.

Ordinary physiological abnormalities, such as high blood pressure, irregular pulse, etc., or emotional instability caused by fear, anger or other disturbing factors, do not interfere with the deception test, because these irregularities are ascertained in the "control" part of the record. In other words, that part of the record made by the subject while being asked the few customary irrelevant question (*e.g.*, "Have you had breakfast this morning?"—requiring an answer of "yes" or "no," without any explanatory remarks) will indicate the physio-

logical and psychological peculiarities of the particular individual. Significance is attached only to the deviations from the "norm" at the points where the subject is being interrogated as to his participation in the crime under investigation. A study of the records pictured herein will illustrate the principle more clearly than words can describe.

Within the past three years at the Scientific Crime Detection Laboratory of Northwestern University School of Law, Professor Keeler and other staff members have examined approximately 3,500 individuals involved in all sorts of crimes, ranging from petty theft to murder, and the results have been very encouraging.

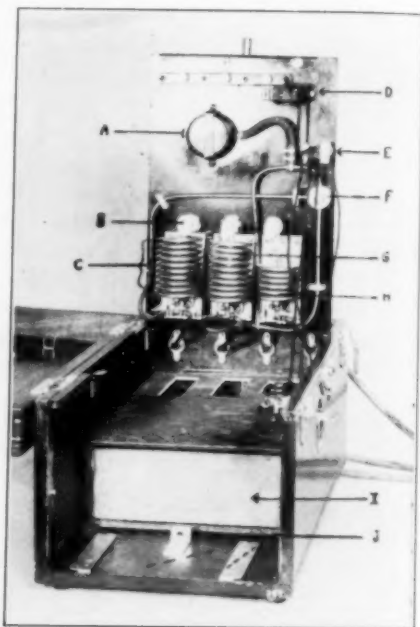


FIG. 2. INTERIOR VIEW OF POLYGRAPH  
A, SPHYGMOMANOMETER; B, PIVOT SHAFT ASSEMBLED; C, TAMBOUR, BLOOD PRESSURE UNIT No. 1; D, SIGNAL MAGNET; E, TOGGLE SWITCH; F, SELECTOR VALVE; G, TAMBOUR, BLOOD PRESSURE UNIT No. 2; H, TAMBOUR, RESPIRATORY UNIT; I, DRAWER COMPARTMENT FOR ACCESSORIES; J, SPACE OCCUPIED BY KYMOGRAPH UNIT (MOTOR, GEAR TRAIN, PAPER ROLL SPROCKET).

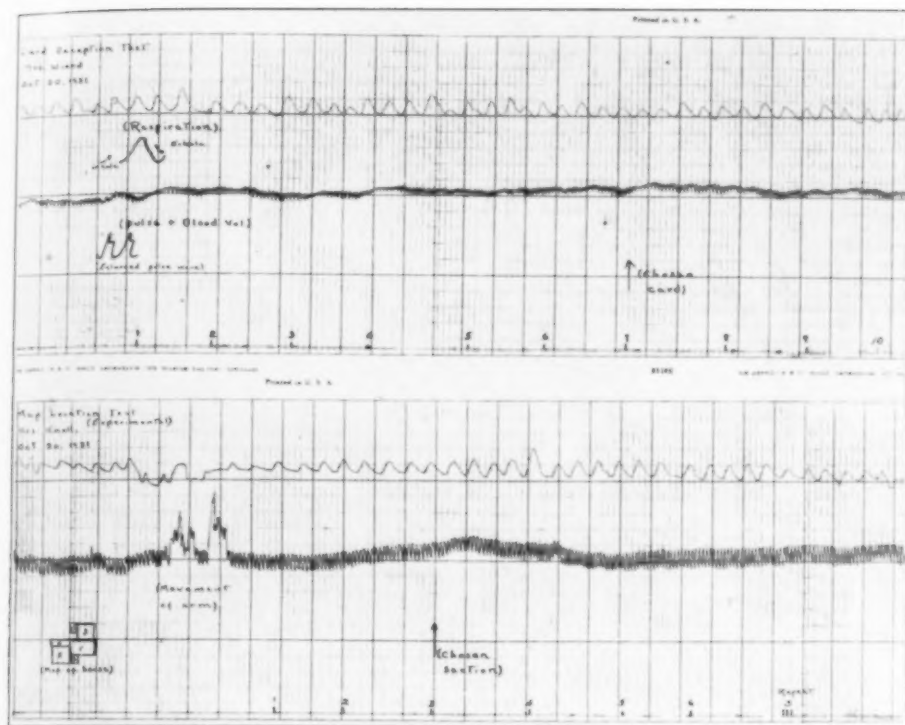


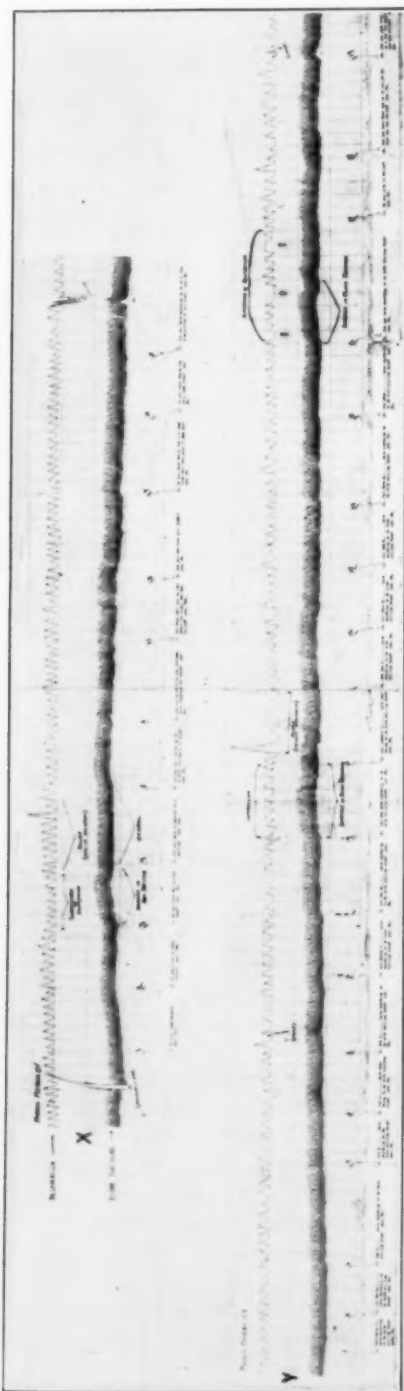
FIG. 3. EXPERIMENTAL RECORDS

THE INSTRUMENT WORKS WITH APPROXIMATELY EIGHTY PER CENT. ACCURACY IN CASES WHERE INDIVIDUALS "LIE MERELY FOR THE FUN OF IT." THE ARROW ON EACH RECORD INDICATES THE PEAK OF TENSION IN THE SUBJECT'S BLOOD PRESSURE CURVE—THE POINT AT WHICH THE LIE WAS TOLD. IN EXPERIMENTAL CASES OF THIS TYPE THE RESPONSE IS INDICATED MORE OFTEN IN THE BLOOD PRESSURE CURVE THAN IN THE RESPIRATORY CURVE.

Although no claim is made as to the infallibility of the Polygraph deception test technique, statistical data definitely establish the fact that it is an extremely valuable method for determining guilt or innocence. In experimental cases (see records in Fig. 3), the outcome of which is of no import to the individual being tested, there is an accuracy of approximately 85 per cent. And frequently in those instances where no significant response is given, if a monetary wager is made with the subject that his lie can be detected (i.e., chosen card, chosen number, etc.), the existence of this "stake" will cause a significant response to be recorded on the instrument. In criminal

cases, statistical data are difficult to obtain. For instance, in cases where a suspect's Polygraph record contains significant responses indicating his guilt, but no substantiating or discrediting evidence is ever obtained by the police, and no admissions are made by the suspect himself, such a record will remain "an unknown quantity" as far as statistical data are concerned. However, in numerous criminal cases, full confessions have been obtained in approximately 75 per cent. of those in which the record indicated deception regarding the pertinent questions propounded of the suspect.

Several months ago, the prosecuting



attorney of Rock Island, Illinois, solicited the services of the laboratory in an effort to solve the murder of a young girl. There were about fourteen people who "might have" committed the crime. All were subjected to the "lie-detector" tests. One gave what was interpreted as being a guilty record. The authorities were so informed. But before any action was taken, this particular individual fled town. He finally returned and made a partial confession. Other evidence conclusively established his guilt, and he is now serving a ninety-year sentence for the offence. The Polygraph records of this case (Figs. 4 and 5) furnish a neat comparison between "guilty" and "innocent" records.

During the past three years approximately 2,000 bank employees in 52 Chicago banks have been examined on this instrument in an effort to detect the embezzlers of various sums of money. From 10 to 25 per cent. of the entire personnel of many banks so examined were found to be lying regarding the thefts of money belonging to the institutions. And practically all such Polygraph records have been substantiated by admissions from the employees themselves.

In one instance a bank desired to detect the embezzler of a sum of \$5,000. Tests were run upon all 56 employees.

#### FIG. 4. A POLYGRAPH RECORD

IN RECORD X NOTICE THE INCREASE IN BLOOD PRESSURE AND THE CORRESPONDING SUPPRESSION IN RESPIRATION AT THE TIME THE ANSWER WAS GIVEN TO QUESTION 3—"DO YOU KNOW WHO KILLED ROSE?" COMPARE THIS RESPONSE TO THE ONE FOUND AT THE TIME OF ANSWER TO QUESTION 4—"DID YOU HAVE BREAKFAST THIS MORNING?" NOTICE THE RELIEF IN RESPIRATION—HEAVIER BREATHING, AND THE NORMAL BLOOD PRESSURE CURVE. IN RECORD Y SIMILAR RESPONSES ARE TO BE FOUND AT THE TIME ANSWERS WERE GIVEN TO PERTINENT QUESTIONS.



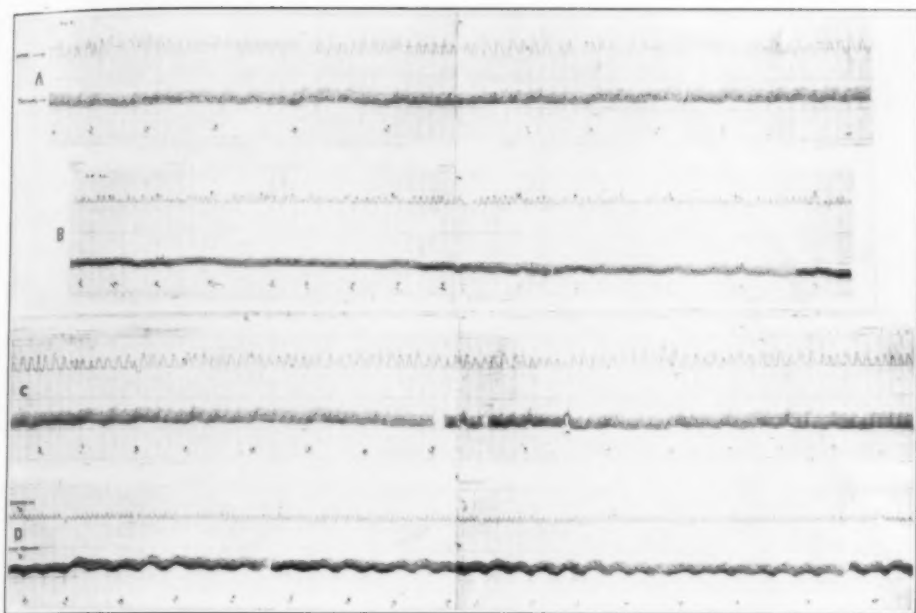


FIG. 5. "INNOCENT" RECORDS

A, B, C, D ARE RECORDS OF INNOCENT SUSPECTS. D ILLUSTRATES THE EFFECT OF MERE NERVOUSNESS IN AN INNOCENT SUSPECT. HIS RESPONSES TO PERTINENT QUESTIONS ARE NO MORE SIGNIFICANT THAN THOSE TO IRRELEVANT QUESTIONS.

but, instead of finding one liar in the group, twelve were discovered. Of the twelve, nine confessed to embezzlements hitherto unknown to the bank officials.

Several Chicago banking institutions will not employ an applicant for a position unless he is tested on the "lie-detector." Fig. 6 is a sample of the type of record frequently obtained in such examinations. In that particular case, after the subject admitted everything he had taken from previous employers, his second Polygraph record was free from significant responses. (Both records were run within ten minutes time of each other.) In such instances as this one the individual is usually recommended as a "good risk." Past experience has indicated that an individual of this type, who readily admits his previous mistakes and irregularities, is not likely to repeat his dishonest practices.

It must be remembered that the successful use of any such device depends largely upon the skill of the operator in selecting the questions propounded and in correlating the emotional responses. This is something an untrained individual can not do. And for that reason Professor Keeler has attempted to limit the distribution of the instrument to individuals who have demonstrated their ability as operators and who are either reputable members of the medical profession, or officially connected with educational institutions or recognized law-enforcing agencies. An instrument of this nature in the hands of an unscrupulous individual is an extremely dangerous thing.

One might naturally inquire at this point as to the admissibility of the "lie-detector" as evidence in a court of law. "If the instrument is as reliable as you



demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field to which it belongs.

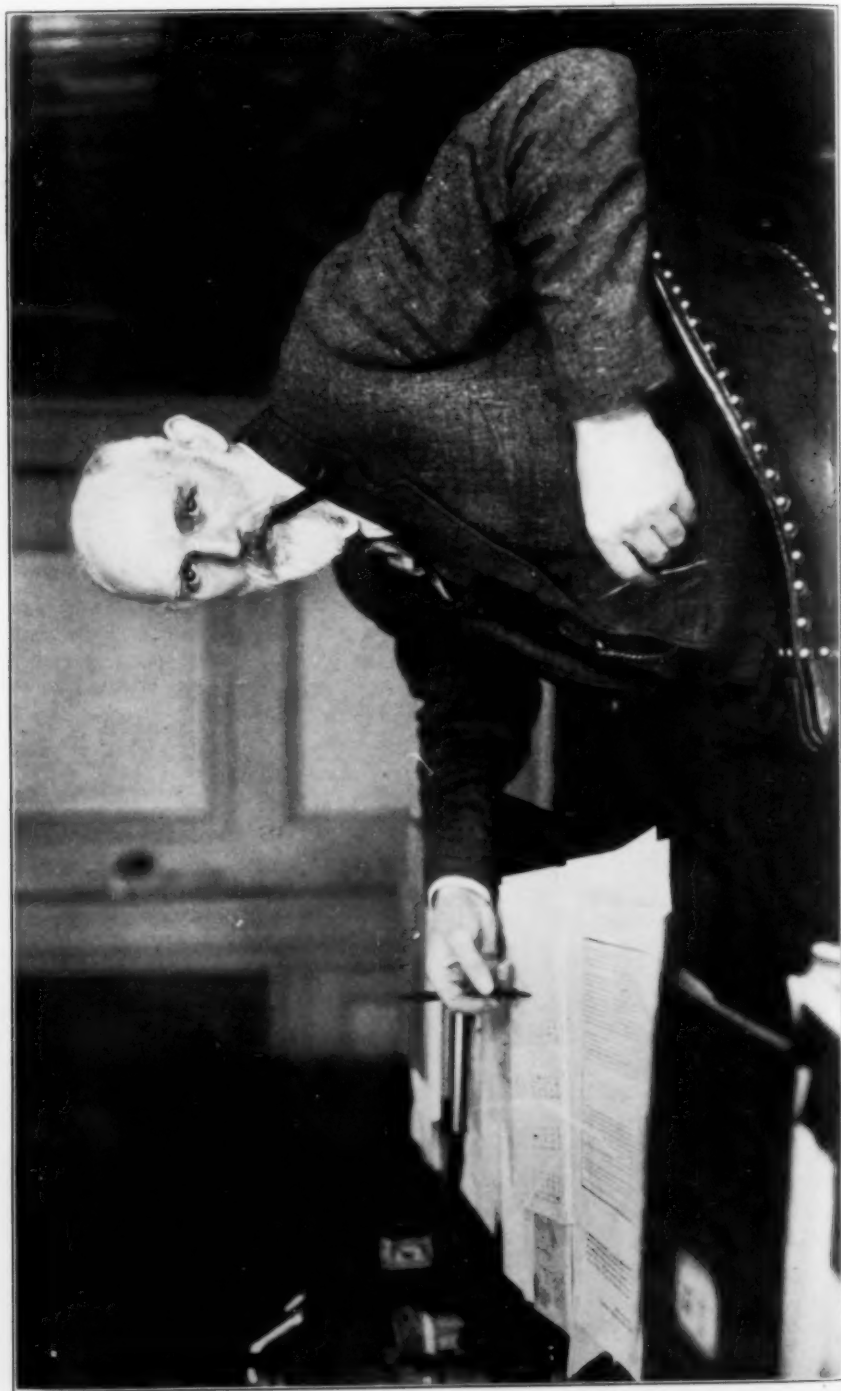
Briefly, here are the reasons for expecting Polygraph testimony to be admitted as evidence. In the first place, the instrument is known to be working with a very high degree of accuracy, and is gradually gaining "general acceptance in the particular field to which it belongs." To be admissible as evidence, however, it need only work with "a reasonable measure of precision in its indications." It need not be proved infallible. Professor Wigmore's "Treatise on Evidence" is the authority for that statement.

At the present time no one is compelled to submit to the Polygraph test. Consequently, if the science of detecting deception by this method is recognized, evidence obtained as the result of a voluntary submission would be admissible in court. Compulsory submission, however, raises another question.

There is, of course, a principle of constitutional law protecting an accused from unwillingly testifying against himself. As to what constitutes self-in-

criminating testimony is the subject of considerable legal speculation. Not everything obtained by compulsion is inadmissible. For instance, an accused person may be compelled to stand up in court for the purpose of identification; to place his feet in a suitable position for view by a jury; to make footmarks for the purpose of comparison with those found at the scene of a crime; to make finger-prints for the same purpose.

"Lie-detector" evidence is of a nature similar to that used in such cases. The Polygraph merely records reactions in a subject's blood-pressure and respiration, when asked questions pertinent to the crime under investigation. And the record is precisely the same even though the subject remains silent instead of replying by the usual "yes" or "no." Therefore, in view of the fact (1) that lay testimony is admissible concerning the physiological and psychological reactions of a person charged with a crime, about the time of its commission, or its discovery, or upon his arrest for or upon his accusation of it; and (2) that compulsory submission to a "lie-detector" test does not constitute "compulsory testimony" (if the analogy to the situations mentioned in the preceding paragraph is valid), it appears that an accused individual may even be forced to submit to the examination.



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## THE PROGRESS OF SCIENCE

WILLEM DE SITTER

THE death of Willem de Sitter on November 20 after an illness of only three days removes suddenly from the stage one of the leading actors in the drama of modern science. He was born on May 6, 1872, in the little town of Sneek in Friesland, Holland. He received his academic training at nearby Groningen in the years when Kapteyn, great astronomer and great teacher, was at the height of his creative powers. After leaving Groningen in 1897 the young astronomer was appointed assistant to David Gill, director of the Cape Observatory in South Africa. Of these two great men de Sitter never lost an opportunity to speak in terms of warmest gratitude. Appointment to a professorship at Leiden came in 1908, and to the directorship of the Leiden Observatory in 1919.

The field covered by de Sitter's contributions is an unusually wide one. At the Cape he gained experience in observing with the heliometer, in photographic photometry and in the measurement of positions on photographic plates. In these early years he became deeply interested in celestial mechanics, choosing for his specialty the theory of the motions of the four bright satellites of Jupiter, a subject that occupied much of his thoughts and energies to the very end of his life. At various times he concerned himself to good purpose with such problems as the earth's variable rotation, the evaluation of the fundamental constants of astronomy, and the determination of absolute star positions. When Einstein, his intimate friend through many years, published his general theory of relativity in 1916, de Sitter turned his attention to this subject. It is through this work that he became known in scientific circles and to the gen-

eral public, although in the writer's opinion it is by no means his most important contribution. His picture of the cosmos became widely known as "the de Sitter universe." This like Einstein's is a static universe, and both have had to give way to one that takes account of the recession of the spiral nebulae, as revealed by the beautiful observations of Slipher at Flagstaff and of Hubble and Humason at Mount Wilson. The currently accepted view of an expanding universe is founded principally upon the work of Friedmann, Lemaitre and of de Sitter himself.

In an entirely different kind of effort de Sitter has made a first-magnitude contribution to astronomy. When he came to the directorship in 1919 he found the Leiden Observatory poorly equipped and even more poorly manned, the staff consisting of two or three assistants and as many clerks. To-day it is one of the leading observatories on the continent. He has gathered about him an exceptionally competent band of enthusiasts numbering about a score, with modern and adequate instruments at their disposal. Best of all he has known how to surround his staff with the atmosphere that makes for growth, and their contributions have played no small part in the recent astonishing developments of their science.

No account of de Sitter, however brief, can omit some mention of his home life. To say that a large part of his success is due to Mrs. de Sitter's devotion is not the platitude it may seem to be. Two sons and two daughters completed the happy circle. All six members of that household could (and did) read in the original the best that English, French, German and Dutch literatures afford, and other modern languages were familiar to at least one of



the group. It was a privilege and a pleasure to listen to the conversation of these intellectual aristocrats.

Although de Sitter's final illness was so brief, it did not come altogether as a surprise. About fifteen years ago he was given an overdose of ether while undergoing a major operation. Phthisis set in as a consequence, and he spent nearly two lonely years at Arosa in

Switzerland. This cured him so far as immediate effects were concerned, but left a serious impairment, and the danger of pneumonia was never absent. It was this disease that finally overtook him and deprived the world of perhaps ten years of his great usefulness.

FRANK SCHLESINGER

DIRECTOR OF THE  
YALE OBSERVATORY

#### AWARD OF THE NOBEL PRIZE IN CHEMISTRY TO PROFESSOR HAROLD CLAYTON UREY

For the second time in succession the award of the Nobel Prize in chemistry has been made to an American chemist. Harold Clayton Urey succeeds Irving Langmuir in the list of Nobel Laureates in chemistry. To both have come world-wide renown by reason of their scientific discoveries. Langmuir's star has shone now for many years with a steady brilliance which has illuminated many hitherto dark regions of the science. Urey's sun has risen, however, with a rapidity which is meteoric in character. Within three brief years, Urey's discovery that ordinary hydrogen gas was not simple, but contained a second isotope of mass 2, has penetrated to the farthest laboratories of the earth and has revolutionized programs of research not only in chemistry but in physics, experimental and theoretical, and in biology. Heavy hydrogen, the isotope with a name of its own, deuterium, has, during these three years, become the subject of upwards of three hundred scientific communications, released at an auto-accelerating pace.

The discovery of a new isotope of an element is not an unusual occurrence. Steadily, since the work of Aston on neon in 1919, element after element outside of the series of radioactive elements has been shown to be composite of two or more isotopes. The extraordinary recent discoveries had been the isotopes of oxygen and of carbon by Giauque and

Johnston and by King and Birge, all of the University of California in 1929. These researches utilized band spectra as a new tool of analysis in the field of isotopes. They led to a calculation by Birge and Menzel that hydrogen must contain a heavier isotope, of mass 2 present to the extent of one part in 4,500. It was this prediction, together with considerations based on systematic arrangements of atomic nuclei which led Urey to his bold and successful efforts, in collaboration with Brickwedde and Murphy, experimentally to demonstrate the existence of such an isotope. The research was conducted in a manner which utilized to the full Urey's excellent theoretical equipment in statistical theory, in atomic and molecular spectra. The record of the work is a fine example of theoretical equipment as a powerful auxiliary to advanced experimental technique.

As is now well known, Urey, Brickwedde and Murphy utilized for purposes of concentration the distillation of liquid hydrogen, and attained approximately a fivefold concentration. The revolutionary character of the discovery only became apparent in the subsequent contribution by the late Dr. Edward W. Washburn and Urey, which demonstrated that electrolysis of aqueous solutions also enriched the residual liquor with the isotope of mass 2. They jointly recorded the importance of these results, pointing out that "we now know that



—Ossip Garber Studios

PROFESSOR HAROLD CLAYTON UREY

that there are large quantities of water in these electrolytic cells containing heavy hydrogen in relatively high concentrations and, also, there is available now a method for concentrating this isotope." Swiftly this conclusion was translated into reality. Within a year, heavy water, pure deuterium oxide, was an accomplished fact.

It was the ease with which the hydrogen isotopes could be separated that gave to Urey's discovery of deuterium much of its epochal character. For the

first time it was now possible to examine the properties of two isotopes of an element in pure form and to verify ideas and theories which previously could only be tested with isotope ratios at best but slightly different from the normal. Especially in the field of molecular statistics and equilibrium, a field intensively developed by Urey in his subsequent researches, in problems of reaction velocity and mechanism, in problems of hydrogen and hydrogen compounds, notably water, including problems of

solutions, of biology and biochemistry, the utility of the separate isotopes was immediately demonstrated. Deuterium, indeed, was more important than a new element, since, by its aid, conclusions could be reached that held also, within limits, for hydrogen and were not obtainable with hydrogen alone.

Urey's discovery of the isotope was perfectly timed from the standpoint of science. It was revealed just as science was learning of the neutron and its properties, just as the nuclear physicist had learned to manipulate the proton as a high speed projectile for the transmutation of elements. Research immediately showed that the deuteron was a far more interesting projectile than the proton. The spectroscopist, too, welcomed the isotope. Isotope effects in spectra are magnified when the mass changes by isotope replacement are in the ratio of one to two. Already the second order refinements of isotope effect in spectroscopy are under study with its aid. In theoretical physics and chemistry, also, in problems of nuclear structure, in problems of zero point vibrational energy and reaction speeds, the isotope became a powerful tool for calculation and subsequent test. In many aspects, Urey's discovery of deuterium may be compared with the discovery by

Christopher Columbus of this continent. He revealed, for others to develop, a rich domain.

This year's Nobel Laureate in chemistry came out of the Middle West, having been born at Walkerton, Indiana, in April, 1893. A graduate of the University of Montana in 1917, he received the Ph.D. degree in chemistry from the University of California in 1923. The following year was spent in Copenhagen, where contacts with Niels Bohr served to complete his education in the mathematical and physical aspects of modern chemistry. From 1924 to 1929 he became one of a very active group of young research men associated with the chemistry department of Johns Hopkins University, whence he was called to Columbia University as a junior professor in 1929. Two years ago he became first editor-in-chief of the new *Journal of Chemical Physics*. Within the present year he has been promoted to a full professorship in chemistry at Columbia, has received the Willard Gibbs Medal of the American Chemical Society's Chicago Section and now joins the ranks of the scientific elect, the third American to win the Nobel Prize in chemistry.

HUGH S. TAYLOR

PROFESSOR OF PHYSICAL CHEMISTRY  
PRINCETON UNIVERSITY

#### THE PITTSBURGH MEETING OF THE AMERICAN ASSOCIATION

THE ninety-fifth meeting of the American Association for the Advancement of Science, together with a large number of scientific organizations associated with it, will convene in Pittsburgh during the Christmas holidays. The meetings begin on Thursday evening, December 27, when the city and the institutions of Pittsburgh will extend an official welcome to their guests in the Carnegie Music Hall. Professor E. L. Thorndike, the distinguished psychologist, president of the association, in a brief address will respond for the visi-

tors. A reception tendered by the Pittsburgh Local Committee will follow.

Pittsburgh has twice acted as host to the association; once in the summer of 1902, and again for the winter meeting in 1917-18. The registration for the latter meeting was only 492, while estimates for the coming one indicate that the attendance will be over 3,000. It seems especially appropriate that the meetings should be held in Pittsburgh, because it is a strong scientific center, especially in the field of the applied sciences. The University of Pittsburgh,



THE CATHEDRAL OF LEARNING OF THE UNIVERSITY OF PITTSBURGH



THE NEW BUILDING OF THE MELLON INSTITUTE OF INDUSTRIAL RESEARCH  
THE ENTIRE THIRD FLOOR OF THIS BUILDING WILL BE USED FOR THE SCIENCE EXHIBITION HELD IN  
CONNECTION WITH THE A. A. A. S. MEETING. GENERAL REGISTRATION WILL BE HELD HERE.

with its magnificent "Cathedral of Learning," the Carnegie Institute of Technology and the Mellon Institute of Industrial Research are among the host institutions.

Registration headquarters will be in the new building of the Mellon Institute, which opens its doors for the first time to a public gathering. This building will also house the science exhibition,

which has recently become an important part of the annual meetings.

The various sections of the association and the societies meeting with it have a full series of papers on their programs. In addition, there are a number of general sessions and events of more than usual interest. Only a few of these can be mentioned here. Full information will be found in the official prelimi-



DR. R. D. CARMICHAEL  
PROFESSOR OF MATHEMATICS, UNIVERSITY OF ILLINOIS; CHAIRMAN OF THE  
SECTION OF MATHEMATICS.



DR. HENRY G. GALE  
PROFESSOR OF PHYSICS, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION  
OF PHYSICS.





DR. JOEL H. HILDEBRAND

PROFESSOR OF CHEMISTRY, UNIVERSITY  
OF CALIFORNIA; CHAIRMAN OF THE  
SECTION OF CHEMISTRY.



DR. FREDERICK SLOCUM

PROFESSOR OF ASTRONOMY, WESLEYAN  
UNIVERSITY; CHAIRMAN OF THE SEC-  
TION OF ASTRONOMY.

nary report published in *Science* for November 30 and in the official program, which will be distributed at the meeting.

On Friday evening the annual Sigma Xi address will be given by Professor E. A. Hooton, of Harvard University, entitled "Homo Sapiens, Whence and

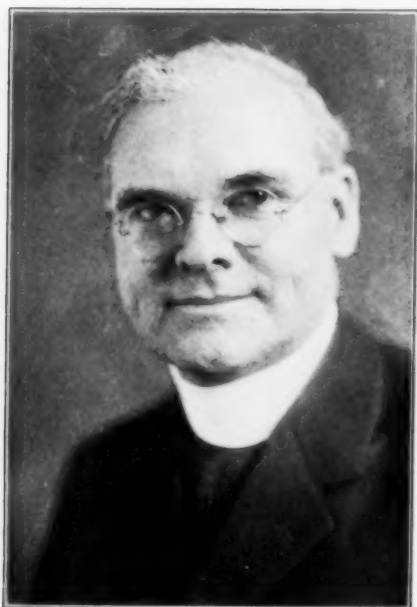
Whither." The address of Professor Arthur B. Lamb, also of Harvard University, retiring vice-president of the section on chemistry, will be delivered on the same evening. His subject will be "Crystallogenic Adsorbents."

The Committee on the Place of



THE QUADRANGLE OF THE CARNEGIE INSTITUTE OF TECHNOLOGY

WITH THE COLLEGE OF FINE ARTS IN THE CENTER. PROFESSOR EINSTEIN WILL DELIVER HIS LECTURE IN THE LITTLE THEATER HOUSED IN THIS BUILDING.



DR. JAMES B. MACELWANE

PROFESSOR OF GEOPHYSICS, ST. LOUIS UNIVERSITY; CHAIRMAN OF THE SECTION OF GEOLOGY AND GEOGRAPHY.



DR. BERNARD O. DODGE

PLANT PATHOLOGIST, THE NEW YORK BOTANICAL GARDEN; CHAIRMAN OF THE SECTION OF BOTANY.



DR. GEORGE L. STREETER

DIRECTOR OF THE DEPARTMENT OF EMBRYOLOGY, CARNEGIE INSTITUTION; CHAIRMAN OF THE SECTION OF ZOOLOGY.



DR. MELVILLE J. HERSKOVITS

ASSOCIATE PROFESSOR OF ANTHROPOLOGY, NORTHWESTERN UNIVERSITY; CHAIRMAN OF THE SECTION OF ANTHROPOLOGY.

Science in Education is sponsoring an all-day symposium on Saturday. Among the speakers will be Professor Edward L. Thorndike, who will make an address on "The Psychology of Attitudes," and Professor Robert A. Millikan, who will speak on "The Present Status of Knowledge of Cosmic Rays."

On Saturday evening, Dr. C. F. Kettering, retiring vice-president of the section on engineering, will deliver his address in the Music Hall. This lecture will be preceded by an organ recital by Dr. Marshall Bidwell. The address of



CARL SNYDER

GENERAL STATISTICIAN, FEDERAL RESERVE BANK, NEW YORK; CHAIRMAN OF THE SECTION OF SOCIAL AND ECONOMIC SCIENCES.



DR. JOHN E. ANDERSON

PROFESSOR OF PSYCHOLOGY, UNIVERSITY OF MINNESOTA; CHAIRMAN OF THE SECTION OF PSYCHOLOGY.

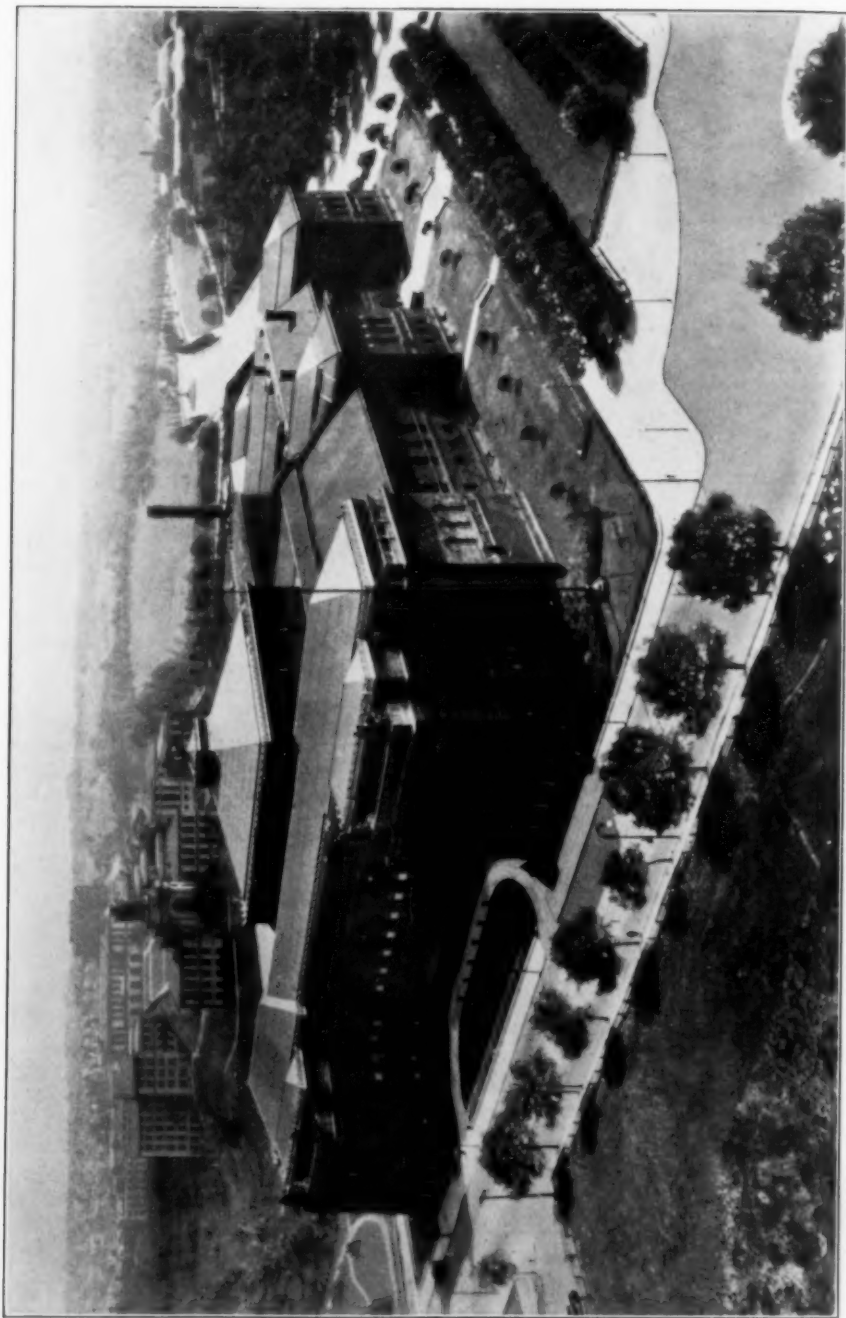
Dr. A. Franklin Shull, president of the American Society of Naturalists, on "Weismann and Haeckel—One Hundred Years," will also be given on Saturday evening.

On Sunday afternoon Dr. Phillips Thomas, of the research department of the Westinghouse Electric and Manufacturing Company, will give a lecture and demonstration known as "Ram-



DR. SOLON J. BUCK

PROFESSOR OF HISTORY, UNIVERSITY OF PITTSBURGH; CHAIRMAN OF THE SECTION OF HISTORICAL AND PHILOLOGICAL SCIENCES.



THE CARNEGIE INSTITUTE BUILDING

WHERE THE RECEPTION AND EVENING MEETINGS WILL BE HELD. THE BUILDINGS OF THE CARNEGIE INSTITUTE OF TECHNOLOGY ARE IN THE BACKGROUND.



DR. CYRUS C. STURGIS

PROFESSOR OF MEDICINE, UNIVERSITY OF MICHIGAN; CHAIRMAN OF THE SECTION OF MEDICINE.



DR. JACOB G. LIPMAN

PROFESSOR OF AGRICULTURE, RUTGERS UNIVERSITY; CHAIRMAN OF THE SECTION OF AGRICULTURE.



DR. C. E. SKINNER

ASSISTANT DIRECTOR OF ENGINEERING, WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY; CHAIRMAN OF THE SECTION OF ENGINEERING.



DR. GUY T. BUSWELL

PROFESSOR OF EDUCATIONAL PSYCHOLOGY, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION OF EDUCATION.



blings in Research" at the Carnegie Music Hall. In the evening the symphony orchestra of the department of music at the Carnegie Institute of Technology will join with Dr. Bidwell in a special recital for members of the association.

Monday evening will be devoted primarily to the address of the retiring president of the association, Dr. Henry Norris Russell, research professor of astronomy at Princeton University, who will speak on "The Atmospheres of the Planets." Of special interest in the mathematical program will be the address of Professor Albert Einstein, who will deliver the annual Josiah Willard Gibbs lecture of the American Mathematical Society. This lecture, the eleventh of the series, will be delivered in the Little Theater of the Carnegie Institute of Technology.

A series of special lectures will be given in the afternoons including a lecture on Thursday by Dr. Cyrus C. Sturgis, director of the department of internal medicine at the University of Michigan. He will review "Some of the More Important Recent Advances in the Study of Blood Diseases." On Friday Professor H. H. Newman, of the University of Chicago, will give a lecture on "Twins Reared Apart and the Nature-Nurture Problem." Dr. Mark H. Liddell, of Purdue University, will speak on Saturday on "The Auditory Spectrum," when Professor C. T. Knipp, of the University of Illinois, will conduct experiments with his singing tubes as a part of the demonstration.

A symposium on the relation between science—and especially scientific organizations and institutions—and the press will be held in the Hotel Schenley on

Sunday morning. Speakers from leading universities will outline the policies and problems of their institutions, and representatives of the National Association of Science Writers, Science Service, the Associated Press, the Hearst Service and several outstanding newspapers will give the association the benefit of their experience and outline the newspaper point of view.

On Friday the sections of chemistry and physics will hold an all-day joint meeting to discuss "Heavy Hydrogen and Its Products." Mathematicians and physicists will hold a symposium on Saturday morning to discuss the "Group Theory and Quantum Mechanics." Several joint meetings have been planned by the section on zoological sciences and also by the botany group. "Science and Technology in Western Pennsylvania" will be the topic of a discussion to be held by the section of historical and philological sciences in conjunction with the section on engineering. A program of addresses of general interest on certain aspects of contemporary economic and social problems under the New Deal is being arranged by the section on social and economic sciences.

The science exhibition will include demonstrations on cosmic ray research contributed by Dr. Robert A. Millikan and Professor A. H. Compton and their associates; displays of the work on deuterium of several laboratories, with a contribution from Professor Harold C. Urey; a model of the stratosphere balloon gondola and its instruments; a model of the Van de Graaff 15,000,000-volt electrostatic generator; and many others of general interest both to the general public and to workers in science.

W. N. J.